15A
~~Mr. Fogg~~ ~~117~~
~~Mr. Cook~~ ~~117~~
Mr. Watt 117
~~Mr. Bishop~~ ~~117~~
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VOL. 8 No. 12 Published Monthly DECEMBER 1959

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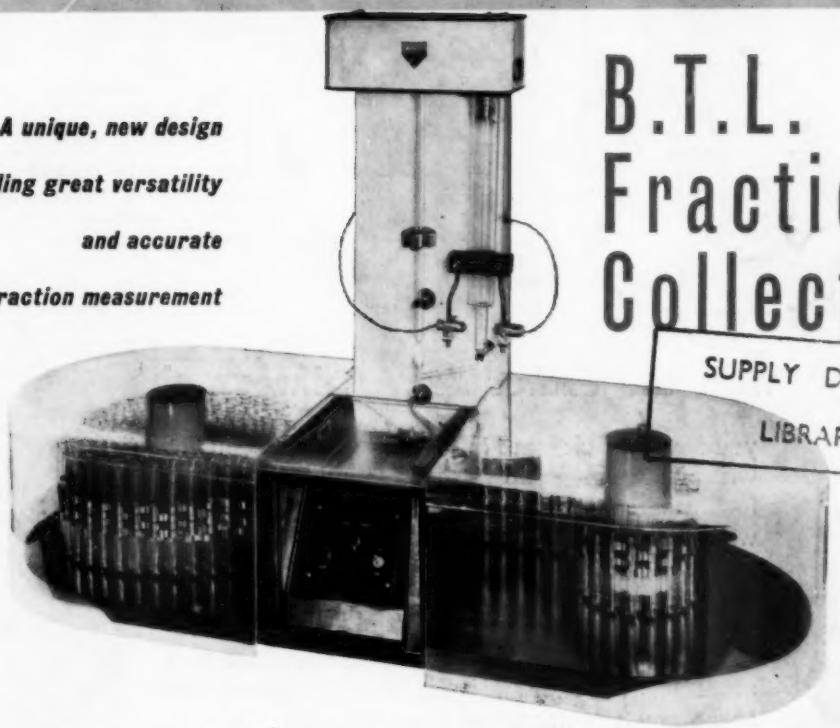

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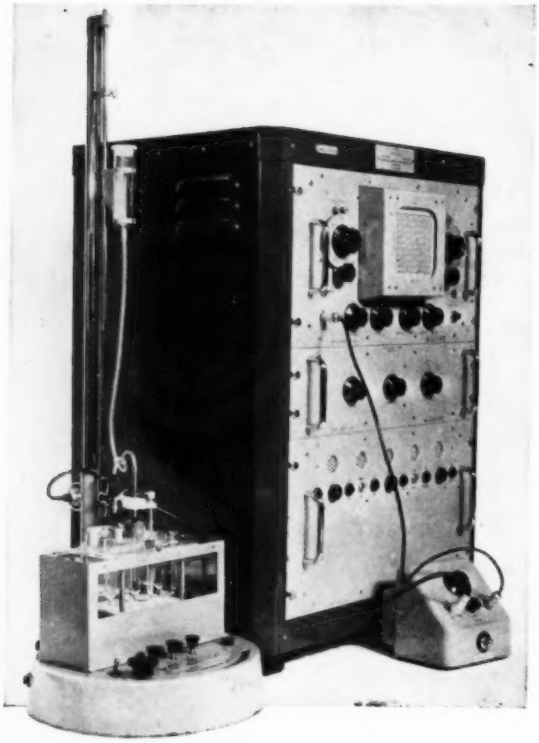

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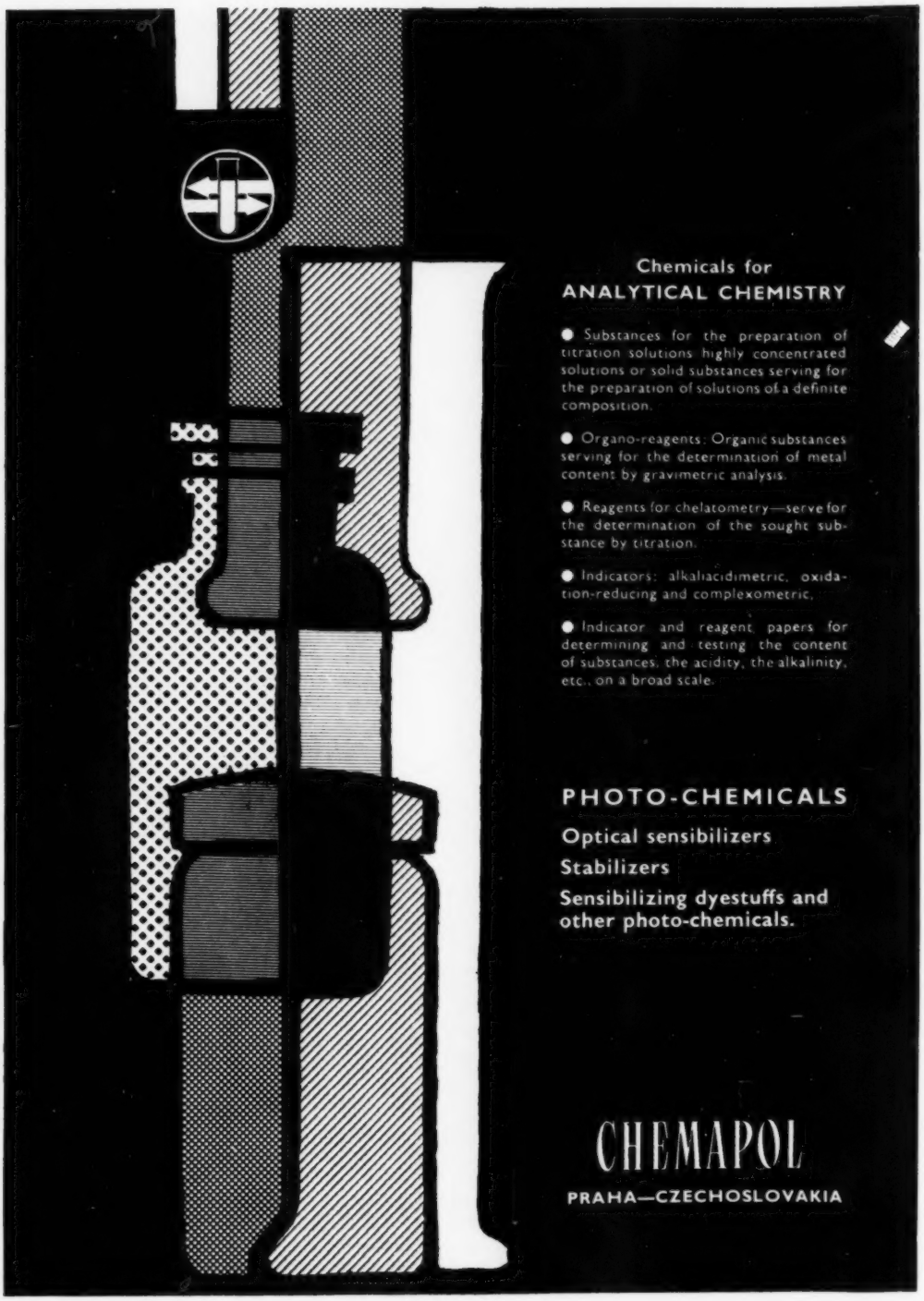
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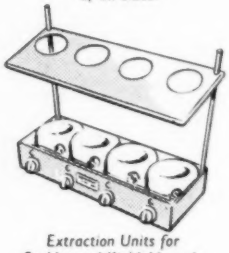

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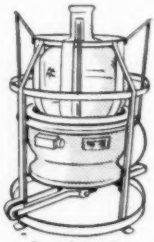

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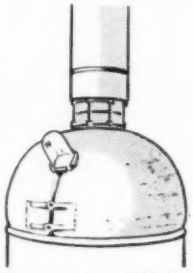

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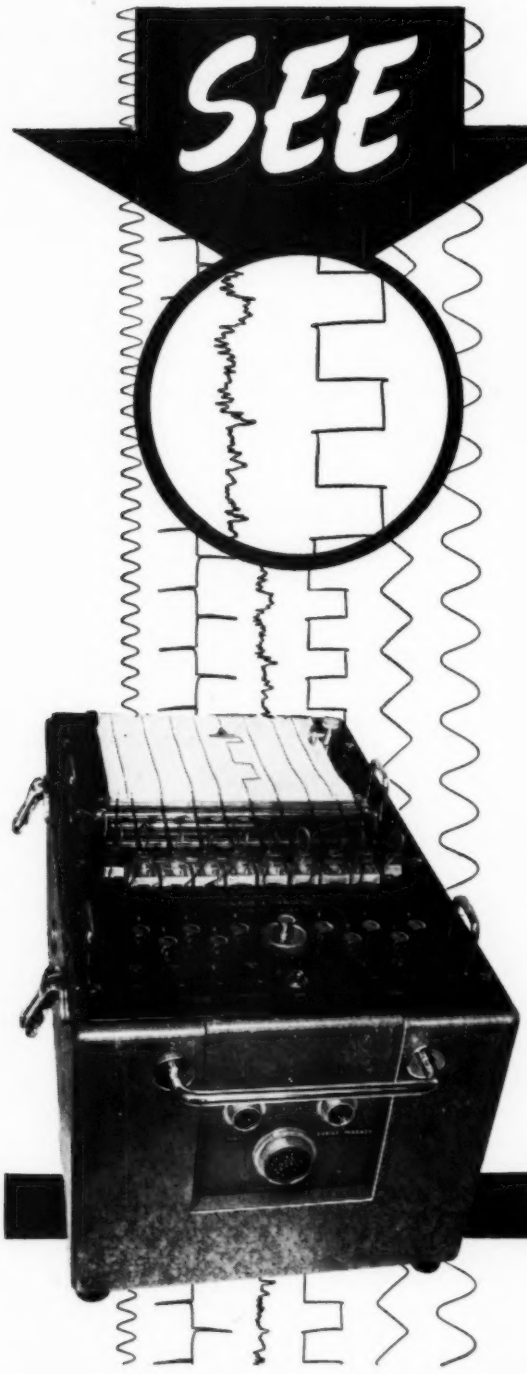

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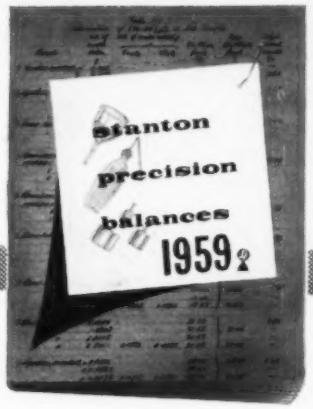

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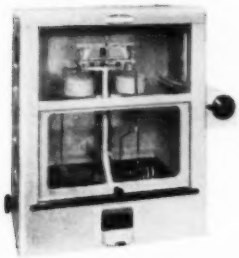

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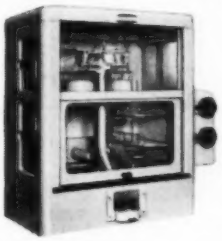

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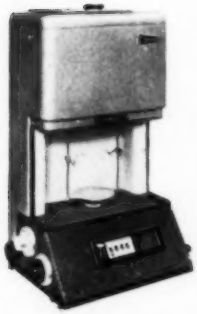

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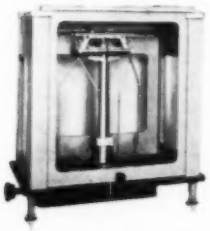

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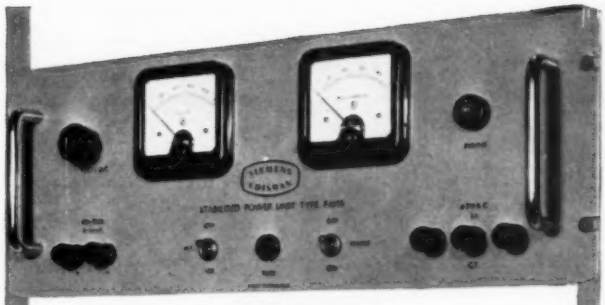

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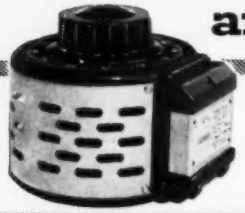

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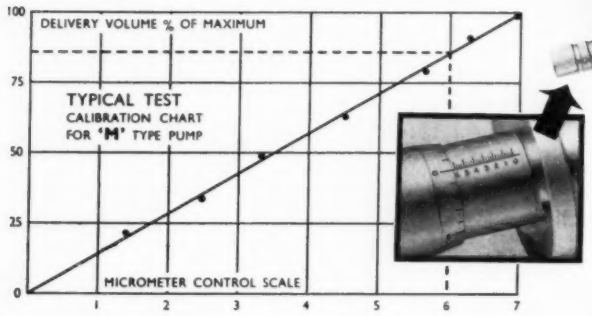

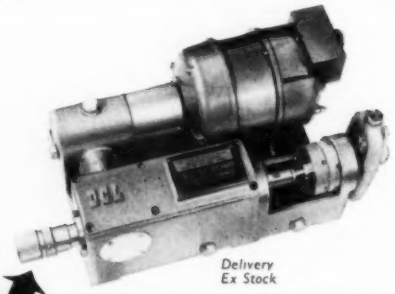

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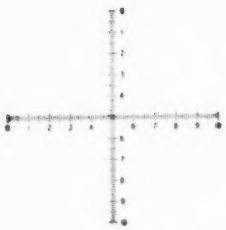
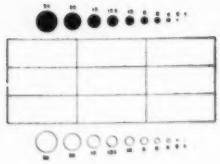
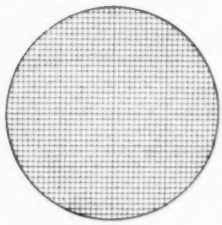
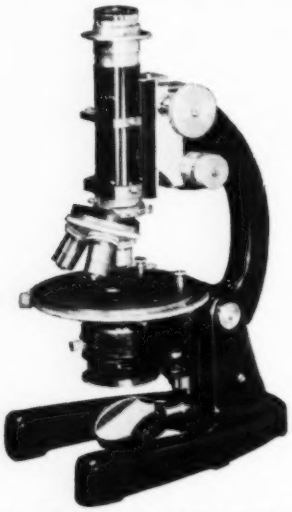
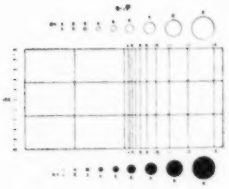
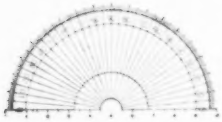
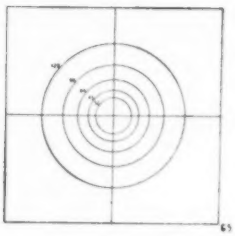

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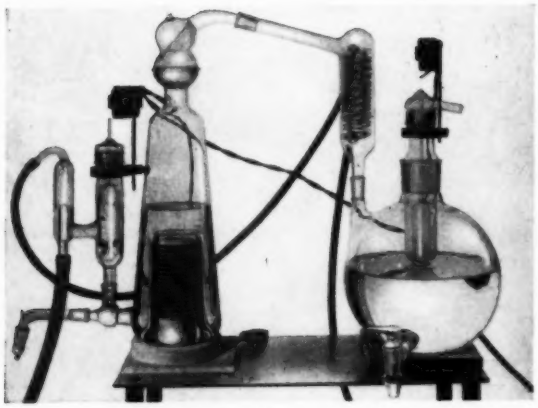

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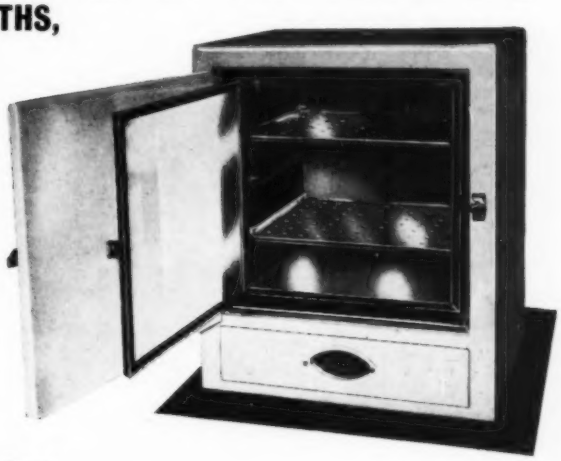

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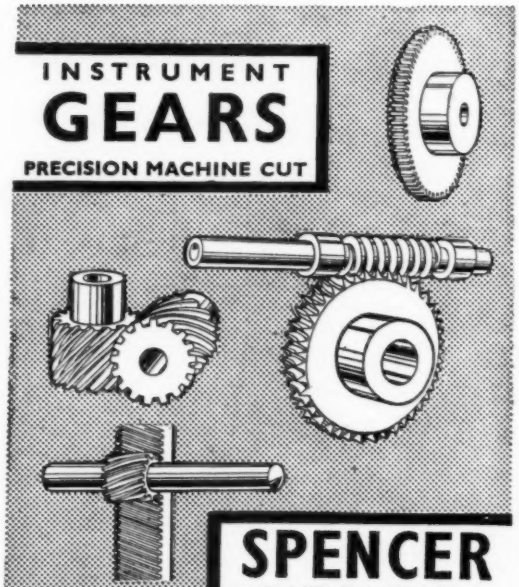

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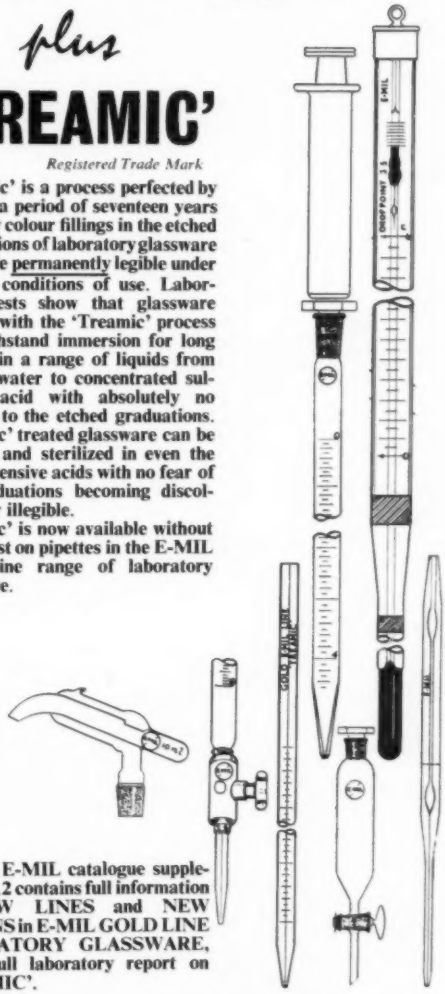

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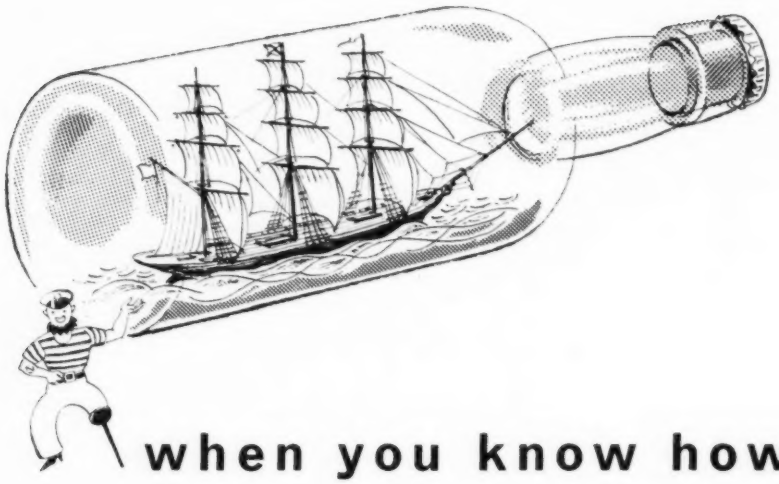

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EDITORIAL

A New Exhibition

ACTIVITIES and functions in the scientific world have multiplied so rapidly lately that there is now almost an automatic resistance to anything new. 'What, another society?' or 'What, another journal?' are expressions not infrequently heard today. There is certainly a good reason why new things should not be started unless there is an adequate demand for them. Societies and publications both take time, energy and money, and like hypotheses should not be multiplied unnecessarily. In practice the law of supply and demand will inevitably operate and if there is insufficient use for the society or journal it will sooner or later fade out.

International congresses are another type of activity which have become very popular in recent years. These combine three functions—the reading of papers and holding of discussions, the publication of (now very weighty) proceedings, and the provision of opportunities for scientists from various countries to get together to talk over their problems. There is now general agreement that the last is the most useful of the three and the second is of doubtful value. Any function which brings scientists together can potentially serve the purpose of the last. Whether it is called a congress, symposium, convention or anything else is really immaterial.

Science is essentially a practical subject and, to be healthy, must always be linked to the laboratory. Theory, hypothesis and even pure speculation have their uses, but divorced from experimental work they soon lead the scientist into a morass of confusion and hopeless error. The great advances of science can frequently be directly attributed to the elaboration of new techniques—the microscope in biology, pure culture methods and the electron microscope in microbiology, high potentials in physics, chromatography in chemical analysis, X-rays in medicine, radar in astronomy, statistical methods in biology especially, and so on. Thus the advances in science are very largely the advances in laboratory technique.

It is common today to hear scientists say that they do not have enough time to read and digest all the journals that come to them, and to attend all the society meetings and congresses of interest to them. There just

is not sufficient time for this. The same reasoning applies to keeping abreast of the advances in scientific apparatus and materials. It is possible by attending demonstrations at society meetings, by combing the literature and by going round to all the manufacturers to follow the advances, but these procedures are very time-consuming. It would be very helpful if all new apparatus could be made available for examination at one place at one time.

This will be achieved next year by the organization of the first comprehensive exhibition of laboratory equipment and materials ever to be held in this country. From time to time specialized exhibitions have been organized by scientific societies, but this will be the first to have a full coverage for all experimental sciences.

The exhibition to be organized by 'Laboratory Practice' will be held at the Royal Horticultural Society's New Hall, Westminster, from June 20 to 23, 1960. The very latest laboratory apparatus will be available for detailed examination and the technical staffs of the leading manufacturers will be present to answer questions.

An interesting feature will be a series of lectures on recent advances in laboratory techniques by scientists of international reputation under the chairmanship of members of our Scientific Advisory Committee. The subjects envisaged include medical biochemistry, chromatography, rheology, bacteriology, analytical reagents, micro-techniques, glass in the laboratory, spectroscopy, ion exchange techniques and metallurgy. Tickets for these lectures will be made available to subscribers to 'Laboratory Practice' in due course.

Recent British Standards

Methods of Testing Vulcanized Rubber

Use of a micro-instrument, for the testing of smaller and thinner test pieces, is the feature which distinguishes this Part of the revised B.S.903 from the standard hardness test specified in Part A7 of the same standard. (Part A.20, B.S. 903:1959, price 3s.). The micro-hardness test—applicable to samples down to 1 mm. thickness—is, in fact, a 'scaled-down' version of the test in Part A7.

Following an explanatory note, separate sections of the new publication deal with: test piece, apparatus, procedure, temperature of test, and form of report.

The standard concludes with a table for the determination of hardness in British Standard and International Rubber Hardness degrees for instruments calibrated in millimetres.

Determining the Bursting Strength of Paper

The latest addition to the eight existing British Standards in the series for paper and board testing methods is this new 32 page publication based on the work of the Technical Section of the British Paper and Board Makers Association (B.S.3137:1959, price 6s.).

B.S.3137 describes the well-known pneumatic and hydraulic types of testers and gives instructions for using them and methods of reporting results.

While the instruments are of the well-known types, it has been found that the variation in results in the past has been quite considerable, and the standard therefore specifies certain details of the instruments more precisely.

The fully illustrated standard concludes with appendices dealing separately with gauge calibration, gauge pointer constants, gauge hydraulic constants, and precision of results.

Laboratory Potentiometric pH Meters

This new British Standard (B.S.3145:1959, price 3s.) specifies performance requirements for laboratory potentiometric pH meters. Its publication is particularly appropriate in view of the issue in recent years of standards for pH scale and for glass electrodes (B.S.'s 1647 and 2586 respectively) and it will in due course be complemented by a specification for deflection pH meters.

Among the performance requirements specified are those for calibration of the scales, sensitivity, stability and input current. Other requirements in the eight-page publication include those for the temperature compensating device, auxiliary pH control, connection to the glass electrode, and for screening.

Meters which purport to comply with the requirements of this specification are required to be marked with its number, i.e. 'B.S.3145'.

Copies of these standards may be obtained from the British Standards Institution, Sales Branch, 2 Park Street, London, W.1.

Analysis and Testing of Coal and Coke

Of the revised edition of B.S.1016 'The analysis and testing of coal and coke', Parts 1-8 and Part 11 have already been issued. Part 12 'Caking and swelling properties of coal', is now available and deals with the determination of the crucible swelling number and of the Gray-King Coke type of coal (price 6s.).

The method for the determination of the crucible swelling number is essentially unchanged, except that electrical heating is now a permitted alternative to gas heating.

The determination of the Gray-King coke type has not previously been introduced in a British Standard, although the coke type has been used for some time as a parameter for coal classification. In its original form the test was known as 'the Gray-King Carbonization Assay at 600° C.' when yields of coke, gas, tar and ammonia were determined in addition to the coke type. The determination in its present form which is now described as the Gray-King coke type, deals only with the assessment of the coke type and is not concerned with quantitative yield.

For coals of high crucible swelling number, the Gray-King coke type was originally determined after dilution of the sample with electrode carbon; it has recently been shown that the latter may be replaced by certain anthracites without affecting the results obtained.

The 22 page publication contains six large and fully annotated diagrams.

Testing of Coal and Coke

This new publication is Part 8 (Chlorine in Coal, price 4s. 6d.) in the programme of revising and issuing in separate parts B.S.1016, 'Methods for the analysis and testing of coal and coke'.

This part deals with the determination of chlorine in the coal sample, previously ground to pass a 72 mesh B.S. sieve, by either the Eschka or the high temperature method. The former method has been slightly modified from the original by reducing the sample weight from 5 g. to 2 g. and increasing the incineration temperature from 450° C. to 675° C.

These changes reduce operating time from about 24 hours to two hours. The high temperature method (combustion in oxygen at 1350° C. and determination of the chlorine by titration as hydrochloric acid) has been introduced to enable results to be obtained in an even shorter time.

Following a clause on definitions, the standard deals with: the coal sample; determination of chlorine; tolerances; reporting of results. The 14-page publication concludes with two full page diagrams.

ARTICLES

SPEEDING UP THE CALCULATION OF RESULTS (WITH PARTICULAR APPLICATION TO FLOWMETER ANALYSES)

by A. T. J. Hayward, B.Sc.(Eng.)

Fluid Mechanics Division, National Engineering Laboratory, East Kilbride, Glasgow

Summary

The calculation of test results is often laborious. In many cases the labour may be reduced by mathematical simplifications which are approximations but within the overall accuracy required.

Examples are given of the application of these techniques to determination of the specific gravity of water, and the calculation of discharge coefficients of venturimeters.

It is shown how these methods cut the time of computation, with resulting increase of output of experimental work.

Introduction

There is no need to stress the point that the calculation of results in engineering laboratories is a wearisome burden. The burden has been growing heavier year by year, not only because the volume of work is increasing, but because modern engineering science is becoming more and more complex, while the standards of accuracy required are continually being raised. In consequence, many types of test which were once performed without refinements and evaluated in a few moments on a slide rule have now been so elaborated that lengthy operations on calculating machines are involved.

Electronic computers have proved the salvation of a number of hard-pressed workers whose subjects happen to lend themselves to that form of analysis. But the majority still have to do their calculations the hard way.

For most workers, any hope of speeding up their calculations lies in other directions. There are a number of simple arithmetical devices whose existence may easily be overlooked, but which can often result in a surprising reduction in the amount of work involved in a set of calculations.

Methods of Simplifying Calculations

Most work in engineering laboratories is of a repetitive character, i.e. the same test is repeated over and over again, either with different test subjects or with the same subject under different conditions. In evaluating the results, the same calculation has to be done over and over again, but with different numerical values each time. In such circumstances, if only a small amount of unnecessary work is done in each calculation, the total time saved by eliminating this waste may be very considerable.

Some useful methods of simplifying repetitive calculations are as follows:

(i) Modifying experimental techniques to suit simpler methods of calculation.

(ii) Combining all the constants, conversion factors, etc., involved in a series of calculations into one numerical constant.

(iii) In a series of tests, some quantity, such as temperature, density, speed, voltage, etc., is often nearly, but not quite, constant throughout the series. It is then often convenient to express the quantity as a product of its mean or nominal value (which can usually be incorporated in the constant mentioned above, method (ii)), and a number very close to unity. Such numbers are very convenient to handle because they can be multiplied together, divided, and raised to powers (including negative and fractional powers) very easily. For example, $(1{\cdot}0012)^{2/3} = 1 + 0{\cdot}0012 \times 2/3 = 1{\cdot}0008$, to a very close approximation.

(iv) The use of specially compiled tables, relating to particular calculations.

The last two methods, used separately or in combination, are particularly useful and deserve to be more widely known than they are.

The techniques described below, which have been introduced to expedite the calculation of the results of tests on flowmeters, afford an illustration of the way in which all four of these methods may be used. It is estimated that the use of these techniques results in a saving of more than a quarter of the time previously spent on these calculations.

Measurement of Specific Gravity of Water

An illustration of the use of methods (i) and (iv) is afforded by the measurement of specific gravity.

At the National Engineering Laboratory the absolute measurement of water flow is made by weighing the discharge during a measured time interval. The conversion of mass-flow readings to volumetric flow rates necessitates a knowledge of the specific gravity of the water used. An accuracy of about $\pm$ 0·01 per cent (1 in 10,000) is regarded as desirable for these specific gravity values, and fluctuations of this order in the specific gravity of the water in the test circuit are found to occur from week to week. Frequent determinations of specific gravity have, therefore, to be made.

The accuracy called for was beyond the range of hydrometers, and a specific gravity bottle method was used. In view of the high accuracy required, both the experimental work and the subsequent calculations

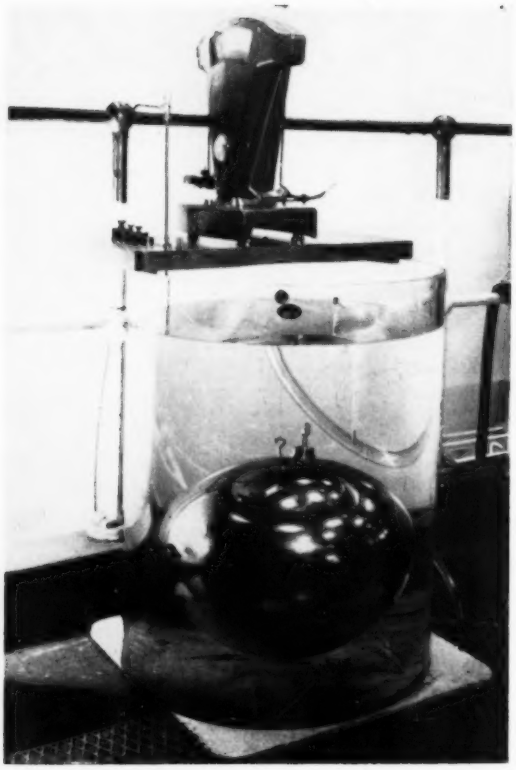

Fig. 1.

were somewhat lengthy. The specific gravity bottle has, therefore, been replaced with the new apparatus[1] shown in Fig. 1 which is much quicker to use, needs no calculations, and is more accurate than the bottle method.

The apparatus is a special form of the physicists' 'hydrostatic balance'. It consists essentially of a hollow sphere, immersed in a Perspex tank containing water, and suspended by a stainless 32-gauge wire from a half-kilogramme semi-automatic balance. The sphere is made from a non-magnetic stainless steel, with an outside diameter of 15 in. and a wall thickness of $\frac{1}{4}$ in. It is loaded internally with lead shot so that it just sinks in water.

Water from the main sump in the hydraulic machinery laboratory is circulated continuously through the Perspex tank. This water is drawn from the 'clean' side of the by-pass filtration system, in order to avoid fouling the sphere with grease and dirt which are usually present in small quantities in the sump.

With this type of apparatus, specific gravity $= \frac{W - W_t}{W - W_d}$ where W = true weight of sphere, i.e. weight *in vacuo;*

W_t = apparent weight of sphere when immersed in the water being tested;

W_d = apparent weight of sphere when immersed in distilled water.

The need to calculate results has been eliminated in the following way. The apparatus has been very carefully calibrated with distilled water at various temperatures and tables based on this calibration have been prepared. These tables relate specific gravity to tem-

TABLE I

Extract from tables for use with the special hydrostatic balance

Weight	°C.							
g.	15·0	15·1	15·2	15·3	15·4	15·5	15·6	15·7
47	193	294	295	296	297	299	300	—
48	290	291	292	293	294	296	297	—
49	287	288	289	290	291	293	294	—
50	283	284	285	286	287	289	290	—
51	280	281	282	283	284	286	—	—
52	276	277	278	279	280	282	—	—
53	272	273	274	275	276	278	—	—
54	269	270	272	273	275	—	—	—
55	266	267	268	269	270	—	—	—
56	262	263	264	265	266	—	—	—
57	259	260	261	262	—	—	—	—
58	255	256	257	258	—	—	—	—
59	252	253	254	255	—	—	—	—
60	248	249	—	—	—	—	—	—
61	245	—	—	—	—	—	—	—
62	—	—	—	—	—	—	—	—

perature and balance reading for the complete range of temperatures and balance readings likely to occur.

A specimen section of these tables is shown in Table 1. The figures in the body of the table are to be written after 1·00, i.e. the figure 293 represents a specific gravity of 1·00293. To use the apparatus, it is only necessary to read the semi-automatic balance and a thermometer which is kept immersed in the tank, and then read off the appropriate specific gravity from the tables.

The whole operation can be performed in one minute.

Comparative tests with the highly sensitive hydrostatic balance at the National Physical Laboratory have shown that the results given by this apparatus are reliable to within 1 part in 50,000. This degree of accuracy is, in practice, unnecessarily high for the present application. It is considered that an accuracy of 1 part in 10,000, which is adequate for most laboratories, could probably be obtained quite inexpensively by the use of a sinker made by loading a Winchester bottle with shot and sealing it with Araldite.

Computation of Venturimeter Coefficients

This affords an illustration of the use of the methods of simplification, (ii), (iii) and (iv).

The Problem.—The aim in the Fluids Division at the NEL is to measure the coefficients of discharge of venturimeters and other pressure-differential flowmeters with an accuracy of 0·1 per cent.

To attain this standard, it is necessary to take into account a number of side effects which can be neglected in less accurate work. These complicate the calculations considerably and, as the 1937 ASME Research Report on Fluid Meters says: 'Making such (tests) over even a limited range of conditions requires the use of much special equipment and involves considerable tedious computation'.

To simplify the calculations, any single effect which, in the worst case, will not cause an error of greater than ± 0·01 per cent in the value of the coefficient of discharge is neglected. This criterion is used to permit a number of simplifying mathematical assumptions, all of which give rise to errors of less than ± 0·01 per cent. The terms 'negligible' and '(not) significant' are to be understood with reference to the same criterion. On this basis a number of minor effects, e.g. the thermal expansion of the flowmeters, may be neglected altogether.

The basic equation for the flow through a venturimeter is:

$$\frac{W}{t}\cdot\frac{1}{\rho_1} = Q = C_d \cdot \frac{A_2}{\sqrt{1-m^2}} \cdot \sqrt{2gH} \qquad (1)$$

where the left-hand side of the equation represents the absolute measurement of the flow rate, Q,—W being the weight of water, having a density ρ_1, diverted in a measured time t. The right-hand side is the flow rate indicated by the meter, multiplied by a coefficient of discharge, C_d, H and g are the measured pressure differential in height of fluid flowing and the acceleration due to gravity.

Rearranging:

$$C_d = \frac{\sqrt{1-m^2}}{A_2} \cdot \frac{1}{\sqrt{2gH}} \cdot \frac{W}{t} \cdot \frac{1}{\rho_1} \qquad (2)$$

i.e.

$$C_d = K \cdot \frac{1}{\sqrt{2g}} \cdot \frac{1}{\sqrt{H}} \cdot \frac{W}{t} \cdot \frac{1}{\rho_1} \qquad (3)$$

where $K = \frac{\sqrt{1-m^2}}{A_2}$ is a 'meter constant', m being the area ratio of the meter and A_2 the cross-sectional area at the throat.

The simple equation (3) is complicated in the following ways:

(a) Conversion factor

It is necessary for equation (3) to be expressed in one system of units throughout. The foot, pound, second system is used generally, but it is customary for the manometers used in the Fluid Mechanics Division of the NEL to be graduated in centimetres and millimetres. To enable manometer readings to be inserted directly in equation (3), the factor 30·48, (i.e. the number of centimetres in 1 ft.) is introduced.

(b) Buoyancy correction

In accordance with Archimedes' principle, bodies are buoyed up by the atmosphere to an extent depending upon their volume. Because of its lower density, water is buoyed up to a much greater extent than the brass weights against which weighing machines are ultimately standardized. Hence, when water is weighed, the weights indicated by the weighing machine are in error. To allow for this, a buoyancy correction β is introduced, defined as:

$$\beta = \frac{W}{W_B} \qquad (4)$$

where W_B is the 'buoyant weight', i.e. the weighbridge reading.

It may be shown that, for the usual range of atmospheric conditions in the laboratory:

$$\beta = 1{\cdot}00106 \qquad (5)$$

(c) Density of water being weighed

The density, ρ_1, of the water passing through the calibration line is not constant, but depends upon:

(i) temperature and

(ii) the specific gravity of the water in the system. (This varies slightly from day-to-day, depending upon the amount of dissolved salts present.)

It is convenient to express $\rho_1 = \sigma\rho_1'$ where ρ = specific gravity of water in the system and ρ_1' = density of distilled water at the same temperature as the water in the calibration line.

TABLE II

Values of Correction Factor

Line Temperature °C.	*Temperature Differences*, °C. (*Line Manometer*)								
	−3	−2	−1	0	+1	+2	+3	+4	+5
16	+27	+18	+ 9	0	− 8	−15	−22	−28	−34
17	+29	+19	+ 9	0	− 9	−17	−24	−31	−37
18	+30	+20	+10	0	− 9	−18	−26	−33	−40
19	+32	+21	+10	0	−10	−19	−28	−36	−43
20	+34	+22	+11	0	−10	−20	−29	−37	−45
21	+35	+23	+11	0	−11	−21	−30	−39	−47
22	+37	+24	+12	0	−11	−22	−32	−41	−50
23	+38	+25	+12	0	−12	−23	−33	−43	−52
24	+40	+26	+13	0	−12	−24	−35	−45	−54
25	+41	+27	+13	0	−13	−25	−37	−48	−58
26	+43	+28	+14	0	−13	−26	−38	−50	−61

NOTES: The figures in the body of the Table represent $(C_1 - 1) \times 10^5$.
The factor C_1 allows for the effect on discharge coefficient of differences in temperature between the manometer and the calibration line.
For use with water-compressed air manometers only.

(d) Manometer differential factors

Two types of manometer are in use for measuring low- and high-pressure differences in the calibration lines. Both are of the 'differential' type in which the weight of a column of a heavier fluid is balanced by the weight of an equal column of a lighter fluid and the static pressure difference being measured. In one, the two fluids are water and compressed air, in the other, mercury and water. For both manometers, a 'manometer differential factor' must be introduced, to convert the displacements shown by these manometers to equivalent heads of a liquid with a density identical to that of the water in the calibration line. The effects of temperature changes on the densities of the liquids involved must be considered, also the effect of changes in the pressure of the air in the water-air manometer.

The complications described under (*a*) and (*b*) are constant and may be dealt with very simply by the introduction of a numerical constant into equation (3). The other effects, however, are constantly varying, and it is primarily in order to allow for them without the necessity of performing complicated calculations for every test point that the new technique has been developed.

Method of Calculation.—The principles of the new method of calculation are as follows:

(i) Equation (3) is expressed in a more convenient form by combining it with equation (4), and replacing $\frac{W_B}{t}$ by the 'apparent mass flow', M.

Then
$$C_d = \frac{KM}{\sqrt{2gH}} \cdot \frac{\beta}{\sigma\rho_f} \qquad (6)$$

(ii) Mean values are assumed for all the variables that give rise to significant effects, thus:

Specific gravity of water in the system 1·0020
Temperature of water in calibration line 18° C.
Temperature of manometers ... 18° C.
Pressure of air in water-air manometers (medium-pressure calibration line)... 40 ft. w.g.
Pressure of air in water-air manometers (low-pressure calibration line) ... 10 ft. w.g.

The subscript '(mean)' added to the appropriate symbol will be used to denote these mean values, e.g. $\sigma_{(mean)}$ denotes the mean value of the specific gravity of the water, which is in fact equal to 1·0020.

(iii) Using these mean values and tables of the physical properties of air, water, and mercury, equation (6) is expressed in the simplest possible form:

$$C_d = \frac{KM}{\sqrt{n}} \cdot \Theta \qquad (7)$$

where h is the actual manometer reading in centimetres and Θ is a numerical constant.

The numerical value of Θ will be different for each of the three cases, water-air manometers (medium-pressure calibration line), water-air manometers (low-pressure calibration line) and mercury-water manometers. Where a high standard of accuracy is not required, equation (7) (in its three forms, corresponding to the three cases described above) may be used directly.

The error caused by neglecting these factors will generally not exceed ± ¼ per cent.

(iv) for high accuracy, however, corrections must be applied to allow for differences between the assumed mean values and the actual values. Equation (7) then takes the form:

$$C_d = \frac{KM}{\sqrt{h}} . \Theta . C_1 C_2 \ldots C_n \qquad (8)$$

where C_1, C_2, etc., are correction factors, each relating to one particular effect.

These correction factors have all been evaluated and tabulated for all the conditions likely to occur in the NEL systems. Since they are all extremely near to unity, they have been tabulated in the form $(C_n - 1) \times 10^5$. Table 2 is a typical example. They may be multiplied together very rapidly by adding the tabulated values together, since $C_1 . C_2 - 1 \approx (C_1 - 1) + (C_2 - 1)$ when $C_1 \approx 1 \approx C_2$. The error involved in this approximation is negligible for the values of the correction factors which occur.

The evaluation of Θ, C_1, C_2, etc., for each of the three cases has already been described in detail elsewhere[2]. As an illustration of the method, the evaluation will be considered here for one case only, namely, that of water-air manometers in the medium-pressure calibration line.

For any differential manometer, the 'differential factor', δ, is given by:

$$\delta = \frac{\rho_{m1} - \rho_{m2}}{\rho_1} \qquad (9)$$

where ρ_{m1}, ρ_{m2} are the densities of the two manometer fluids.

In the present case, at the assumed mean values, the two manometer fluids are, water of specific gravity 1·0020 and temperature 18° C., and damp air at 18°C. and a pressure of 40 ft. water gauge, which has a density of 0·00263 g./ml., equivalent to 62·428 × 0·00263 lb./ft^3. Substitution in equation (9) leads to:

$$\delta_{1(\underline{mean})} = 0{\cdot}99737 \qquad (10)$$

The presence of air in an air-water manometer is usually neglected; equation (10) shows that, even in the NEL medium-pressure calibration circuit, where the head is only 40 ft., neglect of this factor would introduce a systematic $\frac{1}{4}$ per cent error in the measurement of the differential pressure.

Equation (8) now takes the form:

$$C_d = KM . \frac{1}{\sqrt{2g}} . \frac{1}{\sqrt{\frac{h . \delta_{1(mean)}}{30{\cdot}48\, C_1^2 C_2^2}}} . \frac{\beta . C_3 C_4}{\rho_{f\,(mean)}\, \sigma_{(mean)}} \qquad (11)$$

$$\text{i.e. } C_d = KM . \frac{1}{\sqrt{2 \times 32{\cdot}2031}} . \frac{1}{\sqrt{\frac{0{\cdot}99737\, h}{30{\cdot}48\, C_1^2 C_2^2}}} . \frac{1{\cdot}00106\, C_3 C_4}{62{\cdot}342 \times 1{\cdot}002} \qquad (12)$$

where 32·2031 ft./sec.^{2} is the measured value of the acceleration due to gravity in the hydraulic machinery building at NEL, 62·342 lb./ft^3. is the density of distilled water at 18° C. the other values are as given previously, and C_1 is a correction factor to allow for the effect on the discharge coefficient of any difference in temperature between the manometer and the calibration line. C_2 is a correction factor to allow for the effect on the discharge coefficient of variations in manometer air pressure from the mean value of 40 ft. water gauge. C_3 is a correction factor to allow for variations in the temperature of the calibration line from 18° C. C_4 is a correction factor to allow for variations in specific gravity from 1·002.

Equation (12) can then be simplified to:

$$C_d = 0{\cdot}011039\, C_1 . C_2 . C_3 . C_4 . \frac{KM}{\sqrt{h}} \qquad (13)$$

Example.—For a venturimeter with a throat diameter of 4·923 in. and an upstream diameter of 11·973 in., the meter constant, K = 7·4553.

For the medium-pressure calibration circuit with water-air manometers, the circuit constant, Θ = 0·011039.

Hence the combined constant, ΘK = 0·082298.

Given this constant, the results of every test made on this meter in this circuit may be evaluated speedily as follows:

(i) Divide weightank reading by time: $W_B \div t = M$ (calculating machine).

(ii) Look up square root of manometer reading $= \sqrt{h}$ (Barlows Tables).

(iii) Divide M by $\sqrt{h}$ (calculating machine).

(iv) Multiply $\frac{M}{\sqrt{h}}$ by the constant, ΘK, to give an uncorrected* value of C_d to five decimal places (calculating machine).

(v) Look up $(C_1C_3 - 1)$, $(C_2 - 1)$, $(C_4 - 1)$, add them together to give 'Correction' (mentally).

(vi) If, as is usual with venturimeters, $0{\cdot}95 < C_d < 1{\cdot}05$, the 'Correction' may be added directly to uncorrected C_d, to give corrected C_d to five figures (mentally).

Thus:

(i) W = 10·030 lb., t = 81·137 sec., therefore M = 123·612.

(ii) h = 112·2 cm., therefore $\sqrt{h}$ = 10·592.

(iii) $M \div \sqrt{h}$ = 11·671.

(iv) $\frac{M}{\sqrt{h}} . \Theta K = 0{\cdot}96049 = C_d$ (uncorrected*).

*This value is termed 'uncorrected' because the *individual* corrections relating to this particular test point have not yet been made. Corrections of a general character, e.g. buoyancy correction, were included in the constant θ and have, therefore, already been included in this value of C_d.

(v) Manometer temperature = 23° C. $\therefore C_1 - 1 = + 12 \times 10^{-5}$
Line temperature = 22° C. $\therefore C_3 - 1 = + 82 \times 10^{-5}$
Air pressure = 45 ft. w.g. $\therefore C_2 - 1 = + 9 \times 10^{-5}$
Specific gravity = 1·0016 $\therefore C_4 - 1 = + 40 \times 10^{-5}$

'Correction' = $C_1C_2C_3C_4 - 1 = + 143 \times 10^{-5}$

(vi) Corrected $C_d = 0{\cdot}96049 + 0{\cdot}00143$, i.e., $C_d = 0{\cdot}9619$ (rounded to four figures).

Conclusions

In times of staff shortages and large commitments, these methods can be extremely useful. At the NEL it is estimated that about a thousand man-hours are spent each year in evaluating the results of tests on flowmeters. By using the methods described, a reduction of 30 per cent in the time taken should be possible.

But there are wider implications which should not be overlooked. The old irony of the cobbler's children being the worst shod might be applied to the engineering scientist today. He has taught the production engineer to apply scientific principles to his routine work and has, thereby, raised the efficiency of production techniques enormously. But he himself is often content to plough through masses of routine calculations, unaware that a substantial percentage of his drudgery may be quite unnecessary.

We may have to wait a long while for the day when every large research organization has a 'calculation efficiency expert' on its staff; but meanwhile, if all research workers and those concerned with routine testing would get into the habit of examining critically all their own computing methods, a substantial increase in output would surely result.

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The Canadian Society for Clinical Chemistry

The Third National Meeting of the Canadian Society for Clinical Chemistry was held at the Hospital for Sick Children, Toronto, on June 12, 1959. Seventeen papers were presented during the scientific sessions covering a wide range of topics.

Dr. A. L. Chute, Chief of Paediatrics at the Hospital, stressed the importance of communication between the clinical chemist and the clinician, and also the importance of using microprocedures for adults as well as for children. Dr. Guy Nadeau of the Hospital Saint-Michel, Quebec, presented the first paper, outlining a scheme for the routine identification of commonly-used sedatives, hypnotics and tranquilizers in urine. He stated it was possible, with five single extraction steps and five simple reactions, to identify not less than 20 commonly used compounds even at therapeutic concentrations. J. J. Armstrong of the Biochemistry Department, University of Western Ontario, gave details of a chromatographic method for the quantitative determination of free amino acids in serum and urine. Dr. R. H. Pearce of the Department of Pathological Chemistry of the same university presented two papers, one dealing with the use of refractive index in routine analysis as a substitute for specific gravity determinations, the other with the value and design of recovery experiments.

A highlight of the meeting was a discussion of the techniques and uses of starch gel electrophoresis by Dr. Oliver Smithies of the Connaught Research Laboratories of the University of Toronto.

Dr. S. H. Jackson of the Hospital for Sick Children presented an evaluation of the Cotlove chloride titrator, an instrument which had recently been put into use in the routine laboratory for the estimation of chloride in urine, spinal fluid, serum and sweat. Dr. D. B. Tonks of the same hospital discussed the determination of serum cholesterol by the newly-developed Echols reagent, and gave examples of the very large errors which occurred when analysing sera containing high levels of bilirubin. Dr. W. F. Perry of the Winnipeg General Hospital reported on his studies of plasma non-esterified fatty acids in hypopituitary patients, and showed that the concentrations of these fatty acids did not rise in such patients during the course of a 24-hour fast, as they did in normal individuals. Dr. J. J. Caesar of the Montreal General Hospital discussed the distribution and renal clearance of intravenous Mg^{28}, and stated that renal conservation of magnesium seemed to be due to the strong dependence of renal clearance on minute changes of plasma magnesium concentration rather than on indirect lumenal regulation. A modified technique for the determination of blood ammonia by the Conway diffusion method was presented by Dr. D. E. Douglas of the Montreal General Hospital. J. J. Barschel of Regina College of the University of Saskatchewan reported on the effect of temperature, ionic strength, and stoichiometric ratio upon the stability of the colloid formed in the determination of ammonia with Nessler's reagent.

Of interest to haematologists as well as clinical chemists were the following three papers. Dr. M. C. Blanchaer of St. Boniface Hospital, St. Boniface, Manitoba, discussed the characteristics of various paper electrophoretic methods for detecting heme pigments in serum and their usefulness in the detection of intravascular hemolysis. Dr. R. H. Allen of the Laboratory of Hygiene in Ottawa reported on the preparation of cyanmethaemoglobin solutions as reference standards for haemoglobin determinations, and Dr. P. T. Green of Deer Lodge Veterans Hospital, Winnipeg, showed that turbidity arising from increased levels of euglobulin in blood were an uncommon source of error in the determination of haemoglobin by the cyanmethaemoglobin method. Dr. O. V. Sirek of the University of Toronto reported that the prolonged administration of tolbutamide in dogs often resulted in liver cell damage and in derangement of liver function. The final paper was a report on the reproducibility of the procedure for the determination of blood glucose by the Technicon Autoanalyser, presented by C. L. Cousins of the Provincial Public Health Laboratories, Halifax, N.S.

THEORY AND PRACTICE IN THE PHYSICAL CHEMISTRY LABORATORY

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PART I—TEACHING PROCEDURES

THE procedures adopted in a laboratory depend on its function, that is on which branch of science it is used for and whether it is a teaching, research or an industrial laboratory. Here we shall concern ourselves with certain teaching procedures which may be usefully employed in a physical chemistry laboratory in courses leading to higher qualifications.

In theory, the function of the practical period is not only to teach the student the use of his hands or given equipment, but also to make him appreciate the theoretical principles with which he is supposed to have already been imbued as a result of lectures or reading on his own initiative. It should be the aim of persons in charge of the laboratory or the department to combine theory and practice as far as possible. However, as is well known, theory and practice are often wide apart. It is the purpose of this paper to consider some teaching procedures whereby a better co-relation may be obtained between the two.

A great deal depends on those responsible for the organization of the practicals. Two extreme classes of 'authorities' may be recognized: those who consider that the function of the institutions which provide courses for qualifications above the Advanced Level of the General Certificate of Education is to *train* students; there are others who consider that the function of their institutions is to *educate* their students in the particular scientific field. One might perhaps place the first group in the category of persons who are concerned with the training of technicians, and the second group in that concerned with the education of technologists. It cannot be too strongly emphasized that if scientific institutions are not to be relegated to the status of information centres, it is essential to educate the students in the scientific field and not merely to train them. If one does not accept this, then the old definition of a lecture as being 'that process in which the subject matter is passed from the notebook of the lecturer to the notebook of the student, without passing through the heads of either' may well become only too true.

Taking as our starting point the standpoint that we ought to attempt as far as possible co-relation between the lecture room and the laboratory, let us consider the conditions which are conducive to this purpose. A distinction may be drawn between organic and inorganic chemistry laboratories on the one hand and physical chemistry laboratories on the other. In the first two equipment is comparatively cheap and of standard design. It is therefore possible for many students to carry out a given experiment simultaneously. A tutorial preceding such as an experiment may then be used for the whole class. However, most physical chemistry apparatus is expensive and hence only a limited amount of duplication or triplication of apparatus is possible. Consequently, discussion of a given apparatus and experiment is given only to a small group of students; and this talk has to be repeated again and again during the year. This is essential for the following reason. The training of students in practical physical chemistry requires considerable care on the part of both teacher and students, because lack of precaution may result in expensive damage. In inorganic and organic chemistry laboratories, the probability of damage to the comparatively cheap apparatus is considerably decreased by the system of breakage fines which a student may not cherish, but which is nevertheless enforceable. However, it is hardly feasible to fine a student to the extent of even a small percentage of the cost of a highly expensive replacement. It is therefore not only necessary to give an introductory talk on the purpose of an experiment and hints as to the use of the apparatus, but it is also essential to demonstrate the handling of the apparatus. If this is done for only a small group of students carrying out a given experiment, it is necessary to repeat it to other groups of students several times in the year. As will be seen subsequently, the required talks may take from half an hour to three quarters of an hour and when a large class is involved, this means that the demonstrator is tied up with one group and is not available for assistance to the rest of the class. Attempts to discuss each particular experiment once a year in front of the whole class have been suggested. However, it is the author's experience that this method of economy is not successful so far as the teaching is concerned, as the students who carry out a particular experiment weeks after the original discussion and demonstration forget a number of important points, even though certain features of these have been emphasized in their notes.

It has been argued that the use of a practical textbook and an experiment instruction sheet should be sufficient. But this does not hold in practice. Some students do have 'green fingers' in physical chemistry work, but many more do not. A possible parallel is to be found in the theoretical side, where some students can dispense with the lecturer and sometimes get on in spite of him! However, there is no doubt that the majority of students benefit considerably from a system of lectures or tutorials where guidance is given, and where co-relation, comparison and contrast play an important

part. The argument is even more valid for practical classes, because handling of apparatus can be more readily appreciated when seen than when read or heard about.

When one considers a class of 15 students under the supervision of a demonstrator, it can be readily appreciated that *timing* requirements do not allow the demonstrator to spend three quarters of an hour in a talk about the background of the experiment, its ramifications, the experimental procedure and the demonstration itself. Overall teaching time requirements do not allow of the holding of tutorials—which precede the practicals—for small numbers of students. In practice one finds that a rapid *summary* of the experimental requirements and experiment instruction sheets are given to the respective students. Some demonstrators tell the students which experiments they are to carry out and hand out the corresponding instruction sheets several days before the practical is due. However, quite a number of students—particularly evening or part-time day release students—do not look at these sheets until they are in the laboratory, some even lose the sheets without having looked at them. Naturally many demonstrators refuse to lend instruction sheets to students.

The methods to be advocated presently, in an effort to improve instruction in the practicals, may appear to some to amount to 'spoon-feeding' the students. It is therefore desirable to discuss first the *pros* and *cons* of trying to pursue 'ideal' methods of teaching students instead of straightforward lecturing.

In teaching students one is invariably confronted with the problem of how far one should explain the subject and to what extend the student should be encouraged to overcome the difficulties encountered himself without assistance from the teacher. It should be borne in mind that the function of teaching colleges is not merely to pass on information and explain it until it is easily digested by the student; colleges have a duty to develop the student's thinking capacity and his self-reliance in the scientific field in which he is to qualify. We may remember that one definition of an expert is 'a person who need not know the answer to the question immediately, but who knows where to look for the information which will enable him to formulate the answer'. From this point of view, one of the major functions of a teaching institution is to educate the student to a stage when he will be able to formulate the required answers. Naturally, the more digestible the information is made and the better it is presented, the less effort the student has to make to absorb it. It may therefore be argued that there is considerable danger that attempts to reduce considerably the difficulties confronting the student in the practical work will tend to encourage mental laziness thus negating one of the major aims in scientific education. Such arguments deserve serious consideration. However, when we examine the problem we should remember that the student is still required to carry out the experiment himself. Provided that the pre-experiment tutorial or talk covers not only the experiment itself, its background, its uses and limitations and provided that it is designed so as to pose a number of questions to the student which will force him to think, the danger of encouragement to mental laziness on the part of the student may be reasonably ignored.

We may therefore assume that a pre-experimental discussion by a demonstrator to a small group of students —or even one—is profitable. Hence, it is desirable to consider methods which will overcome the time objections discussed. Two methods are feasible:

(a) *Films.*—Films covering a given subject or a branch of physico-chemical instrumentation, such as polarography, are available. Demonstrators or lecturers who have had the opportunity to use them are convinced of their value in teaching. However, the required variety of individual experiment films is simply non-existent. Because of their cost, they are often only hired and are therefore available only for short periods and not throughout the teaching season. Also, a film is normally available only for use in a special large room where a projector and screen are usually placed; this restricts the film use to larger classes rather than to a small audience. Another restriction is requirement of an experienced projectionist. Such restrictions limit effectively the possible use of films in ordinary day-to-day teaching in the practical physical chemistry laboratory, and especially under existing conditions.

(*b*) *Tape-recording.*—About an hour's recording may be made by the teacher and this can be used over and again. The advantages of the system are:

1. Cheapness.
2. Ease of manipulation, no trained projectionist being required.
3. A sound-proofed *cubicle* may be used.
4. Ease of recording the talk.

The recording may be readily stored in the laboratory or in the library and may be borrowed along with a small tape recorder—easily transported by the student.

A film is superior to a tape recording because it can combine both sound and sight, any equations being recorded on it along with pictures and demonstration of the apparatus. Alternatively, the tape-recording can be used with instruction sheets which give the required equations and diagrams and pictures of the apparatus.

Several trials have shown that the latter system is a considerable improvement on the ordinary instruction sheet system. Detailed applications of the system will be considered in later articles. However, its simplicity can be appreciated from a brief résumé of one experiment such as that of the measurement of oxidation-reduction potentials.

The recording lasts about three quarters of an hour. First, the meaning of the term oxidation-reduction potential is considered, not only from the experimental aspect but also from other aspects such as those of free energy changes, reaction prediction, hydrogen electrode and glass electrode pH measurements and so

forth. A number of redox systems are quoted and their significance is discussed. Then follows a brief résumé of the potentiometric *method* of redox potential measurements. During this, the student is referred to numbered equations, circuits and diagrams in the accompanying sheets. The method is compared with that of a voltmeter; the use of valve potentiometers is then considered. There follows a description of the potentiometer to be used, references being made to diagrams, circuits and related points in the accompanying sheet. The importance of an electrochemical convention is explained and reference is made to a calculation on the instruction sheet. Precautions in wiring connections—each end of a wire being labelled by a letter—and the consequences of disregard are emphasized. Finally, questions including appropriate past examination questions are posed, thus leaving the student in a thoughtful frame of mind. A warning to the student not to leave his apparatus in operation at the conclusion of the experiment is included in both recording and diagram sheet.

The use of the tape-recording system as compared to the use of an instruction sheet plus a small talk has resulted in an interesting development. Ordinarily, about a third of the student fraternity attempt to copy as much as possible of the instruction sheet into their experimental write-up, presumably due to their taking the line of least mental effort. However, when tape-recording was used, it was found that the description of the experiment was far more individualistic than in the above. Hence we may conclude that the method used was successful in enhancing mental effort by the students.

It should be borne in mind that where a concentrated mental effort is involved, variation in study techniques may well reduce the resulting nervous tension. A full-time day student follows up his lectures by reading text-books and holding discussions with other students. Alternation of reading with comparatively easier listening to a tape-recording is likely to reduce overall mental fatigue or tension.

Discussions between students tend to act as a challenge to the student and thus tend to develop his thinking powers; it is therefore advisable to include them as part of improved experimental teaching or learning procedures.

It is suggested that before a group of students be allowed to carry out a given experiment they should be guided or goaded into listening to a tape recording concerning the experiment. This should be followed by a short discussion between the students, preferably refereed by a more advanced student who has already carried out the experiment. Finally the experiment is carried out under the supervision of the demonstrator who is by this method, free to attend to the student requirement. The overall effort may appear greater, but the results should amply repay such organization.

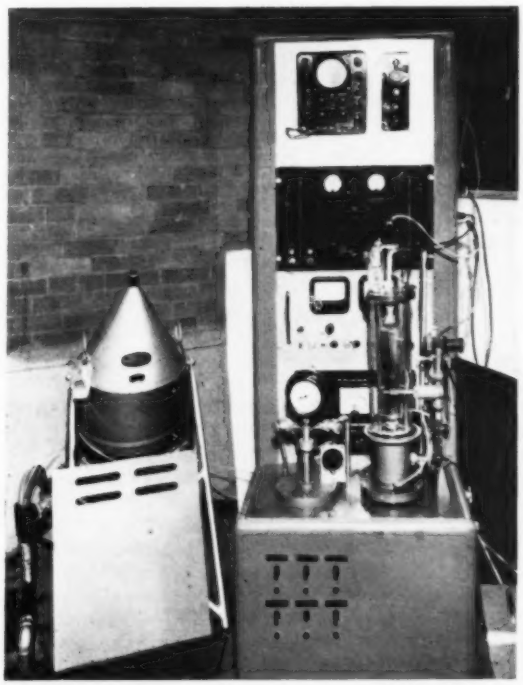
(*To be continued.*)

Ammonia Maser Frequency Standard

Recent reports have appeared in the press of a British molecular clock which has recently been installed in the Melbourne Post Office Research Laboratories, Australia. The development of a portable version of this clock has been undertaken by Glass Developments Ltd., in conjunction with the Ministry of Supply.

In the ammonia Maser, microwave oscillations of very high frequency stability are generated, by the use of a beam of molecules. This is achieved by first allowing ammonia gas to effuse out of a nozzle into a chamber maintained at a very low pressure. The molecular beam formed in this way then passes through an electrostatic field and molecules in an excited energy state are separated out. The molecules selected in this way then pass into a microwave cavity, where they are stimulated to release their energy. If sufficient power is emitted from the molecules the cavity, which is tuned to their resonant frequency, can be made to oscillate. The frequency of this oscillation is so constant at 23,870, 129 Mc/s, that a clock based on it will not lose or gain a second in 100 years. Such a standard of time is sufficiently accurate to measure fluctuations in the earth's rate of rotation.

The development of a miniature instrument will prove to be particularly valuable in navigational aids for ships and aircraft. Application to the measurement of speeds and positions of rockets and satellites is also of major importance. Further, a more accurate frequency standard will be of great use in overcoming interference in very short wave radio communications.



Ammonia Maser frequency standard, shown here with its associated test equipment.

THE LABORATORY ESTIMATION OF CURARE—LIKE ACTIVITY IN NATURAL AND SYNTHETIC PRODUCTS

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PART III

Other Methods

In 1954, Pelikan, Smith and Unna[46] described a method which could be used for the quantitative estimation of neuromuscular blocking activity and also to study qualitative effects. This method employs the gastrocnemius muscle-sciatic nerve preparation of the chicken and has been adopted by other workers.[60] The chicken gastrocnemius preparation is more sensitive to depolarizing-type drugs than to competitive neuromuscular blocking agents.

Leghorn chickens of either sex, weighing between 0·91 and 3·10 kg. are used and anaesthesia induced by slow intravenous infusion of sodium pentobarbitone. As a precautionary measure the trachea is cannulated and artificial respiration provided during the experiment. The tendon of the gastrocnemius muscle is isolated, cut and attached to a semi-isometric lever and the contractions recorded in the usual fashion on a smoked drum surface. A tension of between 100 and 200 g. is placed on the muscle, the value remaining constant during any one experiment. By means of supramaximal tetanic stimulation of the distal end of the cut sciatic nerve (using shielded platinum electrodes) the muscle is made to contract at ten or twenty second intervals. Drugs are administered intravenously by cannulation of either an external jugular vein or a superficial wing vein.

Decamethonium and other depolarizing drugs produce a two-fold action on avian muscle inducing a contracture (i.e. a shortening of the muscle independent of the degree of electrical stimulation) and simultaneously a decrease in the height of the contraction of the muscle to indirect stimulation.

The contracture produced by decamethonium and other depolarizing drugs is measured as the maximum deviation from the base line produced by a given dose of drug and is expressed as the percentage of the maximum contracture induced, at the end of the experiment, by a dose of decamethonium. The dose of decamethonium chosen is the minimum producing the maximum possible contracture for any dose administered. Contractions are measured as the maximum excursion of the writing lever from the base line and the reductions in contractions induced by the actions of drugs expressed as a percentage of the normal contraction height prior to administration of the drug.

A method employing a similar preparation on the pigeon had been described in 1952 by Ginzel and his colleagues.[61] In this method decerebrated animals were used and preparations made on normal and chronically denervated gastrocnemius muscle. A rectifier supplies a direct current and one electrode can be used either as the anode or the cathode.

In addition to the head drop method already described, there have been developed in recent years methods permitting the survival of animals which have received doses of neuromuscular blocking agents otherwise lethal. Chase, Lehmann and Richards[48] compared the relative curarizing action of drugs by noting the dose producing the maximum paralysis which was consistent with indefinite survival. Bovet[6,7] measured the selectivity of action and the degree of curarization of synthetic preparations, while Longo[49] in an extension of this technique using rabbits introduced the *Ten Toxic Doses Method*. By this procedure it was shown that protection could be given by artificial respiration to animals which received ten or more otherwise lethal doses of tubocurarine or up to five hundred times the toxic dose of some synthetic relaxants. This permits determination of the relative duration of activity of various compounds. A further extension of this principle by Bovet[50] and his colleagues led to the construction of an iron lung for dogs. Using this apparatus and administering the drugs under test by a single intravenous injection, Bovet determined the maximum duration of total curarization which permitted complete recovery. He tested several muscular relaxants and expressed the results graphically, plotting the duration of effect as a function of the dose administered. This information is of considerable clinical value.

Qualitative Methods

Experiments using Frog Preparations.—Claude Bernard in 1850[3] first described the site of action of curare using frogs and his classic experimental work formed the basis of many subsequent investigations.[51] Bernard ligatured one hindleg of a frog, thus depriving it of its blood supply but allowing impulses to be conducted along the sciatic nerve. He then injected curare preparations into the ventral lymph sac of the animal and noted the typical paralysing effect produced in all parts of the animal except the ligatured limb. This limb was then stimulated electrically and a muscular contraction was observed while the untreated limb remained insensitive to nerve stimulation. This indicated that the site of action of the drug was at the neuromuscular junction, further proof of which was produced when Bernard showed that the nerve remained capable of conducting impulses when immersed in a solution of the drug.

The frog rectus abdominis preparation, the use of which has already been described, is frequently used for the qualitative evaluation of muscle relaxants and the frog gastrocnemius and sartorius muscle preparations have also been employed.

Frog Sartorius Muscle—Ischiadic Nerve Preparation.—The sartorius muscle of the frog lies immediately under the skin covering the ventral aspect of the thigh.

Frogs of either sex are decapitated, pithed and pinned in the supine position on a dissecting board.

The skin over both thighs is removed and the rectus abdominis muscles carefully freed at their points of insertion into the pelvis. The upper tendinous attachments of the sartorius muscle are thus exposed and a blunt seeker is used to free both the proximal and distal attachments from the underlying tissues. Cotton threads are now tied around both ends of the muscle which is cut free from its attachments to the femur and the pelvic girdle. A slight tension is applied to the muscle by means of the thread tied at each end. The main body of the muscle is freed from the underlying muscles in the leg by blunt dissection except for the bridge of connective tissue in which the thread-like ischiad nerve runs.

The ischiad nerve enters the sartorius muscle roughly midway between the two tendinous attachments of the latter with the femur and pelvic girdle. Having freed and then tied the ends of the muscle, the path of the nerve from the muscle to its junction with the sciatic nerve is traced, and a fine cotton thread tied around the nerve which is very gently freed from the connective tissue surrounding it. When the nerve is freed, the preparation is removed from the leg. Using a fine needle attached to the thread at its proximal end, about 1 cm. of the nerve is drawn through a rubber membrane into a J-shaped fluid electrode filled with double glucose frog Ringer's solution. One end of the muscle is attached to an oxygen delivery tube, the other to a Starling type heart lever fitted so as to record the contraction of the muscle on a smoked surface. The completed preparation is then lowered into a bath containing 80 ml. of double glucose frog Ringer's solution at room temperature. The muscle is stimulated indirectly through its nerve and also directly by means of a Dobbie McInnes square wave stimulator. One terminal of the stimulator is connected to an electrode immersed in the bath fluid, the other to the fluid electrode. This preparation may be stimulated continuously for up to six hours without any signs of fatigue becoming evident.

When the twitch height of the muscle in response to indirect stimulation is uniform, the drug under test, dissolved in frog Ringer's solution, is added to the bath and the effects observed for three minutes. The fluid in the bath is then changed several times from the reservoir. Sufficient time is allowed for the twitch height of the muscle to regain its original magnitude before the next dose of the drug is added. In any one experiment, the voltage, pulse width and frequency of stimulation must remain constant.

Experiments on Avian Muscle.—Paton and Zaimis,[25] Buttle and Zaimis[47] and Zaimis[24] have shown that competitive neuromuscular blocking agents produce a flaccid paralysis in birds, whereas depolarizing agents cause a typical spastic paralysis. These effects can be so strikingly demonstrated that this phenomenon has been adopted as one means of distinguishing between these two classes of compounds. Neuromuscular blocking agents of the intermediate type can also be readily distinguished using this species, and such drugs produce a response embracing that of both competitive and depolarizing agents. Depending on the nature of the compound used, an initial spastic paralysis can be shown to change to a flaccid paralysis in the course of the animal's response to the injected drug.

Zaimis[58] describes the action of tridecamethonium on this species. Initially a contracture appears with the legs characteristically extended but slowly the head drops forward and finally a flaccid paralysis extends to the leg muscles and subsequently the whole animal.

Four to eight day old chicks are used in the experiments. Drugs in solution in normal saline are injected intraperitoneally into groups of six chicks for each compound under test, and the nature and mode of onset of the paralysis which develops is observed.

The method employing the gastrocnemius muscle preparation of the chicken described previously also affords a means of studying the qualitative effects of muscle relaxants on this species.

Experiments using Mammals.—While other species of animals may contribute useful information regarding the actions of muscle relaxants, mammals probably afford the best means of assessing their true effects on human beings. Even so considerable variation between man and experimental animals must be expected and prediction is hazardous on the basis of animal experiments.

Much work has been done using cats, and a detailed description of the method employed to record the electrically induced contractions of the gastrocnemius muscle stimulated via the sciatic nerve has already been described.

Burns and Paton[52] have described experiments using the gracilis muscle of the cat. In these, recordings from the muscle surface were made electrically according to the method of Brown and Burns.[53] Injection into the artery supplying the muscle (close arterial injection) was made by cannulating the femoral artery at a point just distal to the branches leading to the gracilis muscle.

Experiments using the soleus and tibialis muscles of the cat have also been described.[10,25,56,57,58] Paton and Zaimis[54] have indicated the practical significance of the variation in sensitivity of the so-called 'red' and 'white' muscles using this species, while a modification of Brown and Burns method[53] using the gracilis muscle of the rat has been described by Jarcho and his colleagues.[55]

In order to investigate further the phenomenon of species variation, Zaimis[58] used monkeys, dogs, rabbits and a hare. Contractions of the tibialis, soleus and flexor digitorum sublimis muscles induced by supra-

maximal shocks applied to the sciatic nerve were recorded.

No attempt has been made to describe all the methods used in evaluating muscle relaxants. Detailed descriptions of experimental techniques will be found by consulting the original papers.

Side Effects

The clinical usefulness of many drugs is limited by their tendency to produce undesirable side effects. As a class the muscle relaxants are very specific, highly selective and surprisingly free from serious side actions. This is so much the case that the introduction of drugs superior to tubocurarine, gallamine and suxamethonium is likely to be a very difficult task. One major gap remains and that will be filled by a short acting relaxant with a tubocurarine-like action. The initial stimulant effect of the depolarizing drugs and the lack of a suitable antidote are effects directly resulting from their mechanism of action and can only be eliminated by the introduction of compounds which act by a different mechanism. Tubocurarine is a complex molecule and is surprisingly specific. It causes ganglion blockade of moderate intensity and releases histamine. The former may cause a fall in blood pressure and the latter more serious side effects associated with histamine release. Gallamine causes block of the cardiac vagus and gives rise to tachycardia. New compounds are screened to see whether they cause ganglion block, histamine liberation or tachycardia, or any other toxic side effects. Some of the methods employed are outlined below.

Methods Used in Testing for Ganglionic Blocking Activity

Sympathetic Block.—In order to study the ganglion blocking activity of muscle relaxants their effects are studied on the response of the nictitating membrane of the anaesthetized cat to stimulation of the preganglionic fibres of the cervical sympathetic trunk.

Cats of either sex weighing between 2·0 and 3·0 kg. are used, anaesthetized by means of an intraperitoneal injection of sodium pentobarbitone and the trachea and vein cannulae inserted as previously described. The head is rigidly fixed by passing a brass rod between the jaws and tying them firmly together by means of string ties. The ends of the rod are then clamped firmly in place and supported on uprights fixed to the side of the operating table. Using a fine needle a linen thread is passed through the mid-point of the margin of the nictitating membrane of the right eye and tied firmly into place. The thread is now pulled forward and to one side, making an angle of about 30° to the long axis of the cat. It is now led around pulleys and attached to a frontal point writing lever. The contractions of the nictitating membrane are recorded on a smoked surface.

The right cervical sympathetic chain is now dissected and a fine cotton thread tied tightly around it at as low a point as possible in the neck; the chain is severed above the ligature. The cut preganglionic cervical sympathetic chain is now placed on a pair of platinum electrodes and kept moist with normal saline. Contractions of the nictitating membrane are elicited by stimulation of the cervical sympathetic by means of square impulses at a frequency of 800 to 1,200 per minute, at 8 to 15 volts, the pulse width being 0·5 msec. to 1·0 msec. These values must remain constant for any one experiment. Having obtained standard reproducible responses of the nictitating membrane by stimulating the nerve trunk, drugs under investigation are injected into the external jugular vein one minute before the next period of stimulation. This stimulation reaches the nictitating membrane across the synapses of relays of ganglion cells in the superior cervical ganglion and if the drug being tested possesses ganglion blocking activity a reduction in the height or elimination of the contraction of the nictitating membrane will be observed.

Parasympathetic Block.—Several methods are available for testing the ability of muscle relaxants and other drugs to block transmission in parasympathetic ganglia. Feldberg and Lin[62] demonstrated the actions of tubocurarine and local anaesthetics on the isolated ileum of the guinea pig and the rabbit and described a method for quantitatively assaying the potency of curare-like substances. The abolition by tubocurarine of the peristaltic reflex induced in these preparations by raising the pressure in the lumen of the isolated intestine (Trendelenberg[66]) serves as a basis for the identification of parasympathetic blocking activity. In 1949 and using a similar method, Paton and Zaimis[10] also found that pentamethonium and hexamethonium blocked parasympathetic ganglia. Feldberg[63] has also shown that tubocurarine and hexamethonium reduce the response of the ileum to nicotine, demonstrating a method which may also be employed to detect parasympathetic block.

In experiments designed to investigate parasympathetic blocking activity Jacob and Depierre[64] used the response of the dog's heart to vagal stimulation. It was found that gallamine blocks the vagus in this animal at much lower doses than are required to block sympathetic ganglia. Doughty and Wylie[65] observed the clinical effects produced by this drug and found the tachycardia less marked when using cyclopropane than with nitrous oxide-oxygen anaesthesia. In the discussion of this communication Wien indicated that the tachycardia produced by gallamine is not readily apparent in dogs which have an inherent high vagal tone, but might be more readily seen in cats which have a lower vagal tone. After the paralysis of vagal tone by atropine or hexamethonium, gallamine does not produce an increase in heart rate, indicating that it does not have a direct action on the heart.

Histamine Release

The release of histamine by tubocurarine has been described by several investigators.[67,68] Paton and McIntosh[69] studying the effects of a series of organic bases as histamine liberators described a method for measuring histamine release. Cats or dogs were mostly

used in their experiments and the character of the fall in blood pressure induced by histamine itself compared with that produced by histamine liberators (including tubocurarine, dimethyltubocurarine, decamethonium and dodecamethonium). Prior to the administration of these drugs the autonomic ganglia were paralysed using nicotine hydrogen tartrate or tetraethylammonium iodide. Paton and McIntosh[69] found that decamethonium and dodecamethonium were much less liable to produce histamine release than tubocurarine or dimethyltubocurarine. In addition to comparing these compounds as histamine liberators the ratio of the dose producing neuromuscular relaxation to the dose inducing release of histamine was ascertained.

Using the isolated rat diaphragm Rocha E Silva and Schild[70] in 1949 described a method of estimating quantitatively the release by tubocurarine of histamine from striated muscle. In this procedure the diaphragm is dissected out, washed in cold Tyrode's solution and divided into measureable strips of convenient size. A strip of diaphragm is now placed in Tyrode's solution containing a given amount of tubocurarine as a control and a similar strip placed in Tyrode's solution containing a higher concentration of tubocurarine. It is found that in doses much higher than those required to produce neuromuscular block, tubocurarine causes a release of histamine several times that released by the control tissue. Above a certain concentration of tubocurarine the amount of histamine liberated remains constant. Mushin[71] and his colleagues using this method showed that gallamine liberated less histamine than tubocurarine.

The Detection of Toxic Effects on the Central Nervous System

A method of investigating toxic effects on the central nervous system using the electroencephalograph is outlined by Bovet and his co-workers.[50] By this means Longo and Spacarelli[49] were able to study the effects of several neuromuscular relaxants on the functional ability of the central nervous system. The response produced during curarization to certain physiological stimuli (for example flashing) was recorded under these conditions, doses ranging from 5 to 20 times the lethal dose of tubocurarine, gallamine or suxamethonium do not modify the electroencephalogram to physiological sensory stimuli, and while increased doses of tubocurarine may modify it indirectly (due to a fall in blood pressure) no change was found with doses of up to 100 times the lethal dose of gallamine and suxamethonium.

(Concluded)

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Meldola Award for 1959

The Meldola Medal is the gift of the Society of Maccabaeans and is normally awarded annually. The next award will be made early in 1960 to the chemist who, being a British subject and under 30 years of age at December 31, 1959, shows the most promise as indicated by his or her published chemical work brought to the notice of the Council of the Royal Institute of Chemistry before December 31, 1959.

No restrictions are placed upon the kind of chemical work or the place in which it is conducted. The merits of the work may be brought to the notice of the Council, either by persons who desire to recommend the candidate or by the candidate himself, by letter addressed to The President, The Royal Institute of Chemistry, 30 Russell Square, London, W.C.1, the envelope being marked 'Meldola Medal'.

The letter should be accompanied by six copies of a short statement on the candidate's career (date of birth, education and experience, degrees and other qualifications, special awards, etc., with dates) and of a list of titles, with references, of papers or other works published by the candidate, independently or jointly. Candidates are also advised to forward one reprint of each published paper of which copies are available.

U.S. and British Biochemists Honoured

The Nobel prize for medicine is to be shared by two American Biochemists, Prof. Severo Ochoa and Prof. Arthur Kornberg, for their discoveries of the mechanisms in the biological synthesis of ribonucleic acid and deoxiribonucleic acid.

The award is for research close to one of the main interests not only of their own subject, biochemistry, but of biological science as a whole. The nucleic acids, on which they have worked, come into three major but connected problems: the nature of the gene, the unit of heredity; the chemical means by which genes produce their effects; and the way in which proteins, apparently of specific and exactly controlled structure are built up from smaller components in living cells.

Their work has been an outstanding achievement in experimental biochemistry.

Three British biochemists have been awarded medals by the Franklin Institute, Philadelphia. Two of them are the joint winners of the 1952 Nobel prize for chemistry—Dr. A. J. P. Martin, now a director of Abbotsbury Laboratories, and Dr. R. L. M. Synge of the Rowett Research Institute. The third award goes to Dr. A. T. James of the National Institute for Medical Research in London. The medals are for the development of gas-liquid (partition) chromatography.

A SHEEP METABOLIC CAGE FOR MINERAL BALANCE AND RADIO-ISOTOPE EXPERIMENTS

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Introduction

The sheep is used frequently as an experimental laboratory animal, and in the study of ruminant biochemistry and physiology there is now a trend to design experiments similar to those conducted on the traditional laboratory animals. With this development efforts must be made to perform the experimental work with similar attention to experimental detail, and to create conditions in which statistically adequate numbers of these fairly large animals can be handled conveniently and economically.

In mineral balance experiments, and in experiments where radio-isotopes are used the metabolic cage is a necessary item of equipment, on the one hand to allow reliable quantitative separation of urine and faeces in conjunction with controlled food and water intake in conditions of negligible contamination, and on the other to localize in an effective way a radioactive animal and its excrement. The materials and construction of such a cage should allow easy and thorough cleaning and decontamination, and it should be completely adjustable to accommodate sheep of differing size and temperament in comfortable conditions. Robustness and stability combined with light weight are necessary for efficient routine handling and it is a great advantage if the cages can be dismantled completely to occupy minimum storage space.

A cage was developed to satisfy these conditions for use, either with female sheep of any age or moderately sized male sheep, in the new Controlled Environment House for sheep at the Rowett Research Institute (Rowett Institute, 1957). For descriptive purposes the cage is divided into eight components: 1. The framework. 2. The front and trough rack. 3. The door. 4. The sides. 5. The floor panels. 6. The shute and separator. 7. The collection vessels. 8. The food and water troughs. Table 1 gives details of the first four components.

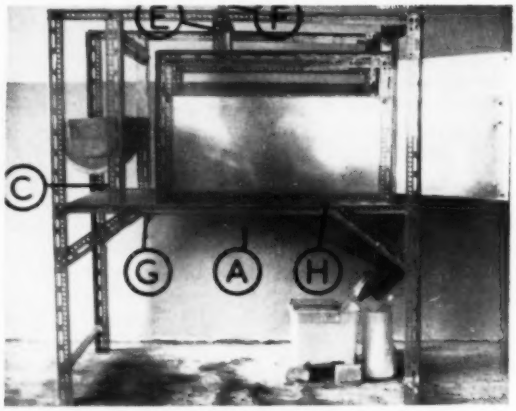

Fig. 1. Side view of cage.

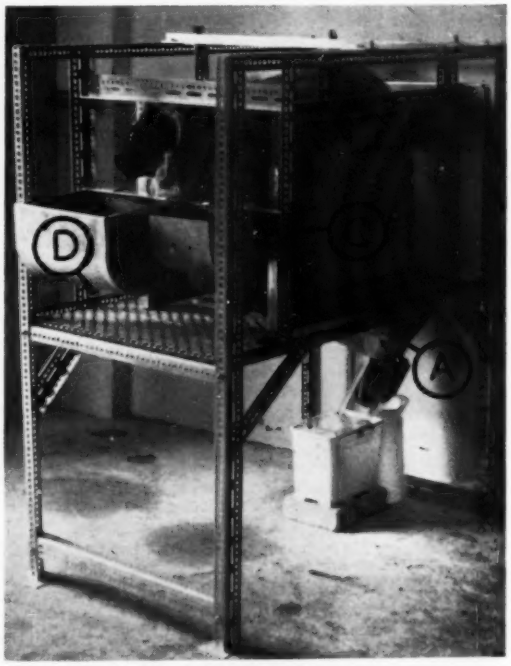

Fig. 2. Front view of cage.

Description of the Cage

1. *Framework.*—The framework of the cage is made of Dexion 225 slotted aluminium angle, flange sizes 2·25 in. × 1·5 in. × 0·092 in. The design of the frame takes account of the range in size of the hill sheep and their crosses commonly available in Scotland. It is based as far as possible on the 10 ft. lengths of Dexion which are marked at 3 in. intervals. This ensures maximum rigidity of structure with economy of material when several cages are constructed.

TABLE 1

Details of components 1-4.

Component	*Part*	*Size ft. in. × ft. in.*	*No.*	*Material*
1. Framework	Corner pillar	5 0	4	Dexion 225
	Side horizontal	4 6	4	,, ,,
	Cross horizontal	2 6	7	,, ,,
	Diagonal support	1 3	4	,, ,,
	Transverse slide	2 6	2	Aluminium angle (1 in. × 1 in. × $\frac{1}{8}$ in.)
2. Front & trough rack	Vertical	2 6	2	Dexion 225
	Horizontal	2 6	3	,, ,,
3. Door	Vertical	1 11½	2	,, ,,
	Horizontal	2 2½	2	,, ,,
	Hinge piece	3	2	,, ,,
	Bolt piece	3	1	,, ,,
	,, ,,	1½	1	,, ,,
	Frame cover	2 5½ 2 1	1	Aluminium sheet (1/16 in.)
4. Side.	Front Vertical	2	1	Dexion 225
	Rear Vertical	2 5	1	,, ,,
	Horizontal	3 0	2	,, ,,
	Mid Vertical	7½	1	,, ,,
	Frame part-cover	3 3 1 6	1	Aluminium sheet (1/16 in.)

The details of the parts required for the framework are given in Table 1, and their dispositions are shown in Fig. 1, 2 and 3. Attention is drawn particularly to the cross horizontal (Fig. 1, 2 and 3A) which supports the ends of the floor panels and the front end of the shute (Fig. 4). The lower edges of the sides are also anchored to this cross member by brass bolts and thumbscrews (Fig. 3B) which run in 5 in. slots cut in the Dexion, between the front and back floor panels, to allow lateral adjustment of the sides. The cage floor is halfway up the structure, that is, 2 ft. 6 in. from the ground.

Fig. 3. Rear view of cage.

2. *Front and trough rack* (*Fig.* 1 *and* 2C *and Table* 1 : 2).—Part of the verticals are cut away on the 1½ in. flange (Fig. 2D) to allow movement between the floor panel and the side horizontal of the cage, for fore and aft adjustment. Two of the horizontals support the food and water troughs at a suitable height while the third is placed so that the sheep can feed but not escape through the opening. The assembly is bolted in any position in front of the sides according to the length of the sheep so ensuring that the sheep's hindquarters are always over the shute.

3. *Door*. (*Fig.* 1 *and* 3, *and Table* 1.3).—The internal surface of the door frame is covered by aluminium sheet which is bent at the sides and top edge to cover the frame and bolted on to it. Two Dexion hinges are attached directly to the door frame, and to a corner pillar by 3 in. lengths of Dexion (Fig. 3 and Fig. 5 I). A simple brass T-piece and two short lengths of Dexion (3 in. and 1½ in.) secure the door (Fig. 3).

4. *Sides* (*Fig.* 1, 2 *and* 3. *Table* 1.4).—The 7½ in. length of Dexion connects the side to the transverse slide formed by the pieces of ordinary aluminium angle (Fig. 1F). Two and a half inches of the 1½ in. flange are cut away at one end and the length is bolted to the top horizontal of the side frame (Fig. 1 and 3E). A 1 in. length of Dexion is bolted at right angles to the free end of the 7½ in. piece, by means of which the side is connected to the transverse slide by a bolt and thumb screw (Fig. 5 II);

Fig. 4. View of inside of cage from the front.

the rear vertical is connected in a similar way to the top rear horizontal of the framework (Fig. 5 III). This arrangement, with the method of securing the lower edges, allows lateral adjustment of the sides. The framework is partly covered by aluminium sheet on the inside, which overlaps the sides of the frame and is hammered back on itself along the top edge. Fig. 4 shows the close box formed by the sides and door, which deflects excreta down into the shute.

5. *Floor panels* (*Fig*. 4).—The front of the cage floor is a single panel of galvanized iron, 28½ in. × 29¾ in., overall and framed with ⅜ in. rod, the mesh being No. 10 wire with a ¾ in. spacing throughout. The panel has two ⅜ in. rods joining the 28½ in. sides at 4 in. and 13½ in. from the rear 29¾ in. edge to support the wire at the two main standing positions. A cross horizontal of Dexion (Fig. 1G) supports the rearmost of these bars at the principal standing position.

The rear of the cage is floored with two panels, each 2 ft. × 1 ft. 2½ in. overall, framed with ⅜ in. stainless steel rod, and having a mesh of No. 10 stainless steel wire with a ¾ in. spacing. The distribution of the mesh in these panels means that along one side and one end the mesh holes are less than ¾ in. The panels are therefore made as mirror images of each other, and are placed in position with the ¾ in. mesh to the inside (Fig. 4). The sizes of these panels are based partly on the dimensions of the cage and partly on the lengths of stainless steel wire delivered to the panel makers, so that waste of this expensive material is reduced to a minimum. These panels are retained in position by brass bolts with washers and thumbscrews through the side horizontals of the frame (Fig. 1 and 3H). If necessary the sheep can be moved right across the cage to stand on one panel while the other panel is removed for cleaning, the sides and shute being moved with the sheep. The 1 in. space between these panels (Fig. 4), does not inconvenience the sheep and it assists the passage of faeces on to the shute. The combined weight of the parts discussed so far is 77 lb.

6. *Shute and separator* (*Fig*. 1, 2, 3 *and* 6 *i and ii*).—The shute and separator are made of stainless steel (20 w.g. F.D.P., No. 1 finish). The shute and three views of the separator are shown in Fig. 6 i, and the dimensions are given in line drawings in Fig. 6 ii. The front end of the shute fits between the Dexion horizontal A (Fig. 3) and the front end of the twin panels (Fig. 4). It is secured to the rear horizontal of the cage floor by the brass bolt welded on to the shute (Fig. 3 and 6 ii). This bolt passes through a slot (5 in.) made by joining two of the Dexion slots, this arrangement permitting movement of the shute. The separator hooks on to the shute (Fig. 3, Fig. 6 ii) and is retained at the correct angle by the brass bolt on the 2½ in. arm of the separator resting in the slot in the 3½ in. arm of the shute. The back of the separator (Fig. 6 i J) is removeable for cleaning.

A toothed piece of stainless steel is welded to the shute (Fig. 6 i K) being set back ⅛ in. from the edge. The teeth and the flaired edges of the shute orifice are set to direct the urine on to the top set of holes and first V of the separator. Two small curved pieces of stainless

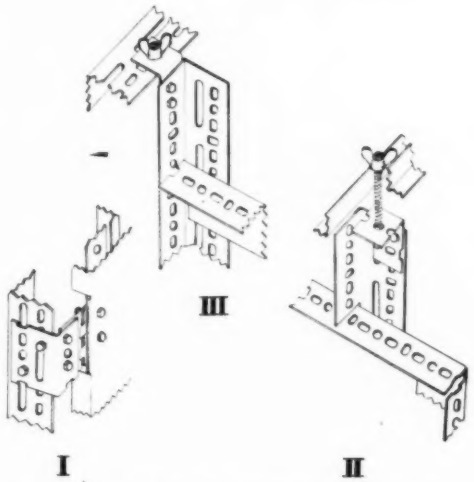

Fig. 5. I. Method of attaching door to corner pillar.
II. Method of attaching the front end of a side to the transverse slide.
III. Method of attaching the rear end of a side to the rear cross horizontal.
All these details are viewed from the side.

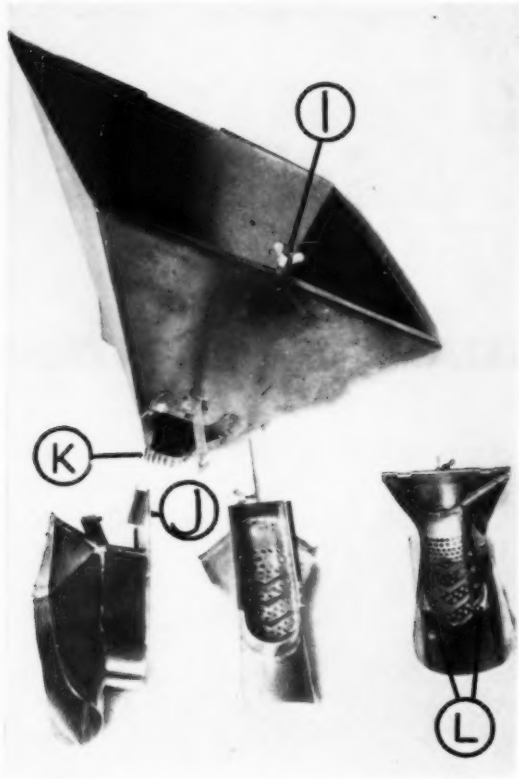

Fig. 6 (i). The shute with three views of the separator.

steel are attached to the separator bed (Fig. 6 i L) to assist the direction of urine into the final V. The V's have a $\frac{3}{8}$ in. space and the angle between the arms is about 115°. The points of the V's are slightly depressed, and the arms are continued a short way up the sides of the separator. The holes are $\frac{3}{8}$ in. diameter.

The weight of the shute is $8\frac{1}{4}$ lb. and the weight of the separator is $1\frac{3}{4}$ lb.

7. *Collection vessels.*—The faeces are directed into a 'Jury' polythene mop bucket. A piece of moulded Perspex covers the open face of the separator and the bucket top (Fig. 1, 2 and 3) to prevent the pellets from bouncing out and to protect the faeces from dust. The urine is diverted into a 6 in. polythene filter funnel which is placed on top of a polythene 'Bex' toilet brush holder of 3 l. capacity or into a 'Jury' mop bucket (10 l.) with a Perspex cover having a 3 in. hole in it.

As small fragments of faeces and small hairs find their way through the separator a filter in the polythene funnel is desirable. It has been found that 4 in. squares of quartz cloth (Refrasil Cloth C-RF-M) are ideal for this purpose since they filter the urine efficiently with virtually no contamination and they are easily cleaned with hot concentrated nitric acid for re-use.

8. *Food and water troughs.*—The normal food and water troughs for the sheep pens are used on the cage. They are made of galvanized iron. The food trough is 14 in. long × 11 in. broad × 9 in. deep and the water trough 8 in × 7 in. × 6 in. For some work, particularly when distilled water is given, it would be better if these vessels were made of polythene or some other inert material.

Cost

The price of the main items is given as a guide to the cost of the cage (Table 2).

TABLE 2

The cost of materials for a single cage, omitting the food and water troughs and the collection vessels.

Items	*Cost* £	*s.*	*d.*
105 feet Dexion 225, with nuts and bolts	11	10	0
$13\frac{3}{4}$ sq. ft. aluminium sheet, $\frac{1}{16}$ in.	2	15	0
5 ft. angle aluminium, 1 in. × 1 in. × $\frac{1}{8}$ in.		9	2
2 Dexion hinges		2	6
2 stainless steel panels	6	4	3
1 galvanized panel		19	0
Shute	8	8	8
Separator	4	4	8
	£34	13	3

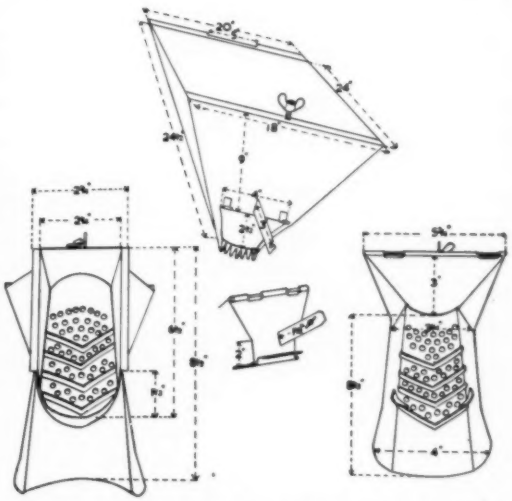

Fig. 6 (ii). Line drawings of the shute and separator giving the salient features, for comparison with Fig. 6 (i). (All measurements in Fig. 6 (ii) are in inches).

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General

The cages have been tested extensively under trial and experimental conditions. Mature ewes of up to 140 lb. and about 3 ft. 4 in. long × 1 ft. 6 in. wide × 2 ft. 6 in. high have been used. The sheep are closely clipped for experimental work where it is considered that this would not produce an alteration in metabolism affecting the study, because the considerable amount of wool that is shed by an unclipped animal can foul the separator. Normal healthy sheep, conditioned to a diet, produce discreet firm faecal pellets and these give excellent separation. There is sometimes slight binding or looseness of the faeces when sheep are introduced to cages for the first time, but, provided that this does not approach scouring, there is good separation of urine and faeces without blockage of the shute or fouling of the separator.

To date, eight sheep are the greatest number that have been caged at once in experiments. In practice there is an extra shute and separator so that each assembly can be removed and replaced with a clean one in a few seconds, and thoroughly cleaned each day. The cleaning is done with a jet of cold tap water and a soft brush or a sponge. The parts are then rinsed with glass distilled water and mopped with absorbent tissue paper before attachment to the next cage. The feeding, watering and cage cleaning can be easily done by one person in a total working time of two hours daily.

It is only a few minutes work to adjust the position of the food rack, the transverse slide and the sides to suit the size and idiosyncrasies of a particular sheep and when this has been done very little additional adjustment is required in the course of an experiment or in subsequent experiments.

ACKNOWLEDGMENTS.—*The author acknowledges the assistance and suggestions of Mr. E. D. Goodall in developing and building the cages. The photographs were taken by Mr. R. Middleton. The shutes and separators were made by the Canal Road (Aberdeen) Sheet Metal Works Ltd., and the author is indebted to Mr. J. A. Tait of this firm for advice.*

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APPARATUS FOR ROUTINE ANALYSIS

by G. Lindley

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PART I—ANALYTICAL APPLICATIONS OF THE KOHLRAUSCH FLASK

This is the first of a five part series describing apparatus developed for use in the routine section of the laboratory.

Introduction

Many analytical procedures involve the dissolution of samples by boiling, very often with subsequent cold or boiling reaction to produce a measurable compound of the element or group being determined. Invariably such procedures are carried out in beakers, and the resultant reaction products are then washed into graduated flasks, and eventually diluted to volume. In routine control work, a great deal of time and expense would be saved if all the procedures could be carried out in a single vessel, and tests with a flask of the Kohlrausch design have shown that this is highly advantageous.

Modified Kohlrausch Flask

Initial tests showed that borosilicate glass avoided breakages due to thermal shock, and a further modification was introduced by terminating the neck of the flask with a standard B24 socket, this in turn being closed by a B24 polythene stopper. The wide neck enables samples to be easily introduced directly into the flask, and also facilitates addition of reagents. So far flasks of 100 ml. and 200 ml. capacity are in use in the routine section of the laboratory and these show a major saving in time and expense. The final design of flask is shown in outline in Fig. 1, and these are now available from Ralph Cuthbert Ltd., Westgate, Huddersfield.

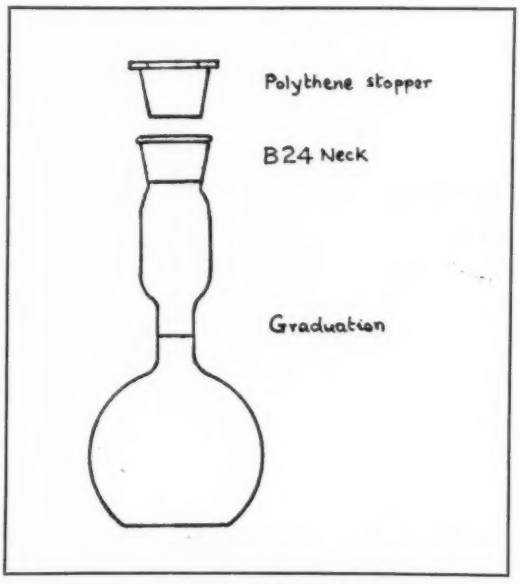

Fig. 1. Modified Kohlrausch flask.

TABLE I

Example of Procedure

Normal Technique	*Common Operations*	*New Technique*
Sample in beaker		Sample in flask
	Add acid	
Cover with clock glass		
	Boil to dissolve	
Remove clock glass		
	Add water Add periodate	
Replace clock glass		
	Boil 10 minutes	
	Cool in bath	
Remove clock glass Transfer to grad. flask Wash into grad. flask		
	Dilute to volume	
	Mix and complete	
14 operations		8 operations

Applications

An example of one of the many applications of the flask is in the absorptiometric determination of manganese in iron and steel. The weighed samples are normally transferred to beakers and solvent acid added. The beakers are covered with clock-glasses and the samples dissolved by boiling. The manganese in solution is then oxidized by boiling for a timed period with potassium periodate, and the beakers placed in a cooling bath. The beaker contents are then washed into 100 ml. graduated flasks and diluted to volume. Almost half of the above operations have been eliminated by transferring the weighed samples directly into the Kohlrausch flasks and carrying out all the operations, including hot-plate work, bath cooling and bench work in these flasks. This example is outlined in Table I.

When solutions are boiling on the hot plate there is sufficient length of neck to ensure adequate reflux, thus minimizing evaporation and spraying difficulties, and as a result of this, clock-glasses are not required. When clock-glasses are used with a large batch of beakers on a hot-plate it is often very difficult to move the clock-glasses to make reagent additions, particularly with beakers towards the rear. Further advantages in the use of these flasks are that considerable economies in glassware are possible, much less bench space is occupied by glassware, and washing up and storage requirements are greatly reduced.

The flasks are universally applicable to any analytical work involving operations similar to the example shown, and are particularly advantageous in large batch work.

The very small nett volume change involved when solutions are boiled and then cooled in their flasks, before final dilutions to the standard volume, is negligible in normal work and no loss in accuracy is incurred. Indeed, transfer errors are avoided.

ACKNOWLEDGMENT.—*The author is indebted to Ralph Cuthbert Ltd., Westgate, Huddersfield, who have co-operated in supplying flasks to meet the necessary requirements. Acknowledgment is also made to the English Electric Co. Ltd. for permission to publish this paper.*

A SIMPLE ROTATORY EVAPORATOR

by W. Brady, A.I.S.T., and J. B. Thomson, B.Sc., Ph.D., A.R.I.C.

Department of Chemistry, University College, Dublin

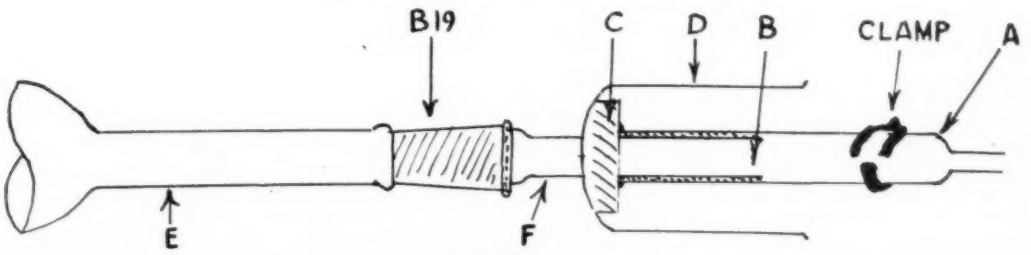

Fig. 1.

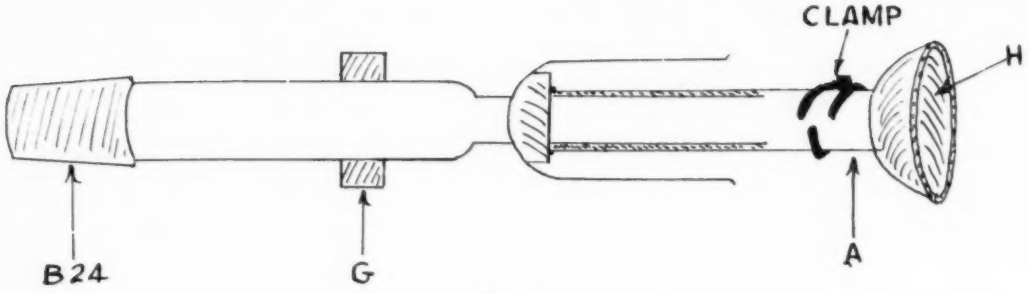

Fig. 2.

AN air-tight spinning joint for a rotatory evaporator with a non-rotating solvent recovery vessel has been described by Bocock and Gilbert (1956). This joint, of polythene, although excellent in use, requires careful machining. The apparatus described below (Fig. 1) can be constructed in a few minutes from parts readily available in most laboratories. The spinning joint is a precision tubing vacuum stirring adapter* the outer sleeve of which (A) is the stationary part and is connected by means of pressure tubing to an ordinary condenser and the vacuum line. The sleeve is a sliding fit on the inner tube (B) and bears on a polythene collar (C) at the bottom of the lubricant cup (D). The joint remains air-tight at a pressure of 10 mm. of mercury. The flask containing the solution to be evaporated is attached to the standard joint and is best supported at the neck (E) by a pair of rubber tyred wheels—an excellent support can be constructed from Meccano parts. The apparatus is rotated by means of a rubber band drive from (F) to a stirring motor.

If frequent use is to be made of the evaporator it is more convenient to construct an extended joint (Fig. 2) which is supported in a polythene bush (G). The stationary sleeve (A) may be fitted with a ground glass ball and socket joint (H) if all glass apparatus is desired.

*Supplied by Quickfit & Quartz Ltd., serial number ST 10/2-53A.

REFERENCE
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A PARTITION CHROMATOGRAPHIC COLUMN FOR FRACTIONATING 50 g. BATCHES OF PLANT EXTRACT

by G. S. Pope

National Institute for Research in Dairying, Shinfield, Reading.

OWING to the great sensitivity of the biological and chemical tests for many biologically-active substances, attempts are often made to isolate such substances even when they are present in very small quantities in extracts of plant or animal material, and it is well-known that the success of these attempts in obtaining the substances in good yield, sometimes in obtaining them at all, is dependent on the employment of one or more of the chromatographic or batchwise countercurrent techniques. It may be desirable to introduce these techniques at a fairly early stage in the isolation procedure, when, for example, the active substance may still constitute less than 1 per cent of the partly purified mixture; it is then necessary to choose a technique which is capable of dealing with large batches of mixture. When the substance sought after is virtually non-volatile relative to the commonly available solvents the choice may rest between: adsorption or ion-exchange chromatography, batchwise countercurrent distribution between immiscible solvent phases and column partition chromatography. Of these the advantages of the batchwise countercurrent method, developed by Craig and Craig (1956), have been recently considered by Thompson, Curl and Bickoff (1959). In our laboratory the use of a 4 in. diameter partition column packed with kieselguhr according to the recommendations of Martin (1949) has been of great value in the isolation in good yield of the oestrogenic substance, miroestrol, from the plant *Pueraria mirifica*, (Pope, Grundy, Jones and Tait, 1958). It has been operated with solvent systems very similar to those of Bush (1952).

Construction

The column consists of a 5 ft. length of industrial glass pipe-line of 4 in. internal diameter suspended vertically (Fig. 1). At its lower end is a glass adapter (A1) reducing the internal diameter to 1 in. and below this a second adapter A2 carrying a B24 cone at its lower end to which a glass stop-cock of 0·5 in. bore is fitted, the hollow key of this being held in place with a spring (not shown

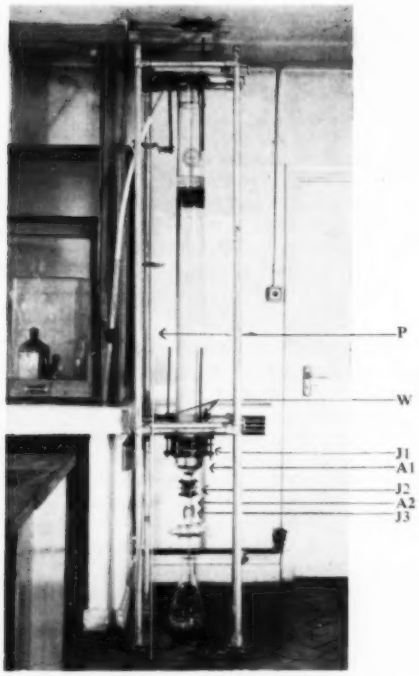

Fig. 1.

in figure). The stop-cock is provided with a micro-groove to facilitate control of flow of solvent. All glass parts are Pyrex. Joints (J1) and (J2) are buttress-type having pressed, asbestos-fibre gaskets sheathed with polytetrafluorethylene film. Joint (J3) is a B24 cone and socket and is sealed with Picien wax (Edwards High Vacuum Ltd., Crawley, Sussex). J1 is pulled tight by means of cast iron flanges fitted over the glass above and below the joint. Each flange, which is separated from the glass by a ring of thick woven asbestos, has six evenly spaced, drilled lugs on its outer circumference, three of which (120° spaced) are used for 5/16 in. diameter bolts, 4 in. long. J2 is similarly made tight except that the cast-iron flanges have only the three drilled lugs.

The column is suspended near the lower end by three 5/16 in. threaded steel rods passing through the other three holes drilled in the flanges at J1 and is similarly suspended near the upper end. The upper ends of each set of rods pass loosely through a horizontal platform constructed by welding 1¼ in. × 1¼ in. angle steel. The weight is taken on six wing-nuts (W) some of which are visible in Fig. 1. The horizontal platforms, each of which is movable in its horizontal plane, rest on members of a framework made of steel piping (1 in. external diameter). By means of these arrangements the column may be moved vertically through about 1 ft. and adjusted accurately to a vertical position.

Inside the column near its lower end a perforated stainless steel disc, 3⅞ in. diameter, 1/16 in. thick and having 40 3/32 in. diameter holes just overlaps and rests over the inner circumference of the sheathed gasket at J1.

The column and support as described were made up from standard parts supplied by Q.V.F. Ltd., Fenton, Stoke-on-Trent, for less than £50. The glass adapter (A2) has since been replaced by a stainless steel part having an integral flange taking the bolts for tightening the joint (J2). This has also enabled larger springs to be fitted to keep the conical joint (J3) tight.

The packing rod (P) has a stainless steel shaft ¼ in. diameter, 5 ft. long in three detachable sections, and a head of stainless steel 1/16 in. thick, 3⅞ in. diameter and provided with about 40 3/32 in. diameter holes. This is serviceable but a packing disc drilled with about 100 1/16 in. holes would probably be rather better.

Operation of Columns

The column is packed and operated as first described by Martin (1949). The immiscible solvent system most commonly used in our laboratory is made by equilibrating toluene, ethyl acetate, methanol and water in the ratio 1·2 : 0·8 : 1·0 : 1·0 by volume, a variant of the systems used by Bush (1952). Commercial grades of solvent obtained in 5 gal. cans are used. Kieselguhr used as inert support is Celite 545 (Johns Manville Co. Ltd., London). It is recovered for re-use by drying in a warm room, followed by heating for 16 hr. at 600° C.

A 20 litre batch of solvent system is first made up, then 3 kg. of Celite 545 well mixed with 1·5 kg. of lower phase of the solvent system in a 20 litre polythene bottle. Two layers of filter paper are placed over the perforated disc at the bottom of the column and the Celite—lower phase mixture added to the column in portions, each portion being first slurried with upper phase and so transferred. After each addition the mixture is packed as tightly as possible by means of the packing disc. Upper phase (which in this case is the mobile phase) collects over the top surface of the compressed Celite and is run out through the stop-cock as necessary and reused, the surface of the mobile phase always being kept above the packing. After 20 to 30 additions the column will be completely packed. In a representative case the compressed Celite was 94 cm. high, 10·5 cm. diameter and the volume of mobile phase held in the packed column, measured by difference, was 5·25 l. Care must be taken to ensure adequate ventilation of the laboratory during packing operations. In our laboratory partly purified extract (50 g.) from *Pueraria mirifica* estimated by bioassay to contain 0·3 g. miroestrol, is dissolved in 40 ml. of stationary phase and the solution intimately mixed with 80 g. Celite 545. This mixture is then loaded on to the top of the column, using mobile phase (minimum quantity) to assist the transfer, and pressed into a cake at the top of the column about 8 cm. in depth. The column is then developed with mobile phase in the normal manner, maintaining a head of about 30 cm. of solvent above the top of the packing and a flow rate of 1 l./hr. An initial effluent fraction (F1)

of 4·25 l. is collected, then 12 more fractions (F2-F13; each of 1·25 l.). Each fraction is evaporated to dryness under reduced pressure and the residual matter collected in a little solvent, dried and weighed. In our experience with this solvent system it is possible by distilling the fractions completely, in a still isolated from the vacuum pump, to recover the mobile phase and recycle it. The column described can in fact be packed and operated with 10 l. of mobile phase. Miroestrol is shown by paper chromatography to be present in F7, F8 and F9 the total weight of which (mean of 10 experiments) is 5·3 g. Further purification of this active material is obtained by chromatographing a second time on a similar partition column.

Evidence that the column described is behaving as a normal partition chromatogram as regards the movement of the substance, miroestrol, was obtained from Van Duin's equation (1952) $\alpha = \frac{R_a - V_L}{V_s}$ where α is the partition coefficient, i.e. ratio of concentration of substance in stationary phase to that in mobile phase; R_a is the apparent retention volume, i.e. volume of mobile phase issuing from the column while the middle of a zone (the volume in the column occupied by a substance) moves from the top to the bottom of the column; V_L, V_s are respectively the volumes of mobile and stationary phases in the column.

In the experiment described, α for miroestrol was found by direct measurement to be 3·74. V_L and V_s are constants for a given packed column and for the representative one of 94 cm. height were 5·25 l. and 1·61 l. Thus R_a calculated from Van Duin's equation is 11·3 l. R_a was measured by taking the mean of the total column effluent to the beginning of the first 1,250 ml. fraction which contained miroestrol and of the total effluent including the last 1,250 ml. fraction containing miroestrol. It was found to be rather variable and the mean of values over 10 column chromatograms was therefore taken. This gave a value for R_a (measured) of 11·25 l.

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THE NEW MINISTER FOR SCIENCE EXPLAINS HIS TASK

THE proposal for a Minister for Science was first talked about when we were preparing the Conservative Manifesto. I was myself at first very sceptical.

It seemed to me that there were two very great pitfalls to be avoided. On the one hand there was the danger that the scientific world—the Royal Society, the Universities, the industrial scientists, the Atomic Energy Authority and the Research Councils (the Governing Boards of which are very largely manned by volunteers) would think that too much was intended, and that the new Minister would interfere with the independence and integrity of the scientist in his own sphere. If that danger were not avoided I feel that I should lose the confidence of those on whom all else depends and whose co-operation I must win if I am to succeed at all. I hope and believe my appointment has allayed these fears. After all I am the same man who has been Lord President of the Council for the last two years. My general attitude to science and scientists has been made plain to those who were interested, and I believe has won confidence. No change in that general attitude is involved in the new appointment. I have no authority over the Universities to compel them to do anything they do not wish to do. My authority over the Atomic Energy Authority and the Research Councils is no greater than my predecessors and I had before, and I have no intention of taking away from them the authority which Parliament has given to them, or the freedom which they now enjoy to perform their functions without detailed interference. I am there to give them general guidance and to help them in their relations with Government, especially other Government Departments.

But an equal and opposite danger is to be expected at this point. I can almost hear the cynical comment. 'New Presbyter is but Old Priest writ large'. The Manifesto promise, the new Minister, is just a piece of political window dressing. Nothing more is to be expected and everything will go on exactly as it was before. I hope and believe this is a mistake, and I would not have accepted the appointment had I believed otherwise.

All the same I would like to make it plain at the outset that this is a long range project. You must not expect clutches of satellites to be flung into orbit in a miraculously short space of time. Sponsors of ingenious inventions will be disappointed. The Minister is not a repository of brilliant new thoughts which have failed to appeal to anyone else. He is not an overlord to the Minister of Education and will not therefore be able to create vast new academies of science and technology. He is not Master of the Queen's Rockets and will not therefore play a decisive part in the politics of guided missiles. He is not a super Minister of Power nor a Minister of Transport, Agriculture or Health. Indeed I must emphasize that unless all the other Ministers in the Government—I think without exception—are at least as scientifically minded as I ought to be myself, my work will be frustrated—and until they are my work will be incomplete. I do not think it is necessarily a disadvantage that I am not a professional scientist. The First Lord of the Admiralty is not a naval officer; the Minister of Transport would not necessarily be better for being a railway man. In the main, Parliamentary Government is Government by amateurs advised by experts. The one exception is the Lord Chancellor, and he has a technical legal job to do. In my own case I believe that the appointment of a non-scientist as the first Minister will compel scientists to do the most urgent thing, that is to share in the thought about scientific policy themselves.

For, whether or not there is need for a Minister or a Ministry, two years' experience as Lord President has

convinced me that there is need for a policy for science and that policy cannot be the product of Government thinking alone.

In describing my task I will start by one or two general propositions. Science in this country increasingly touches life at every point. It is thus necessarily a partnership—and, since this country is a democracy, it is necessarily a partnership in which everyone is invited to play a part. But the indispensable partners are industry, agriculture, medicine, teaching, the Universities and Government—and of course both the scientists and the non-scientists who play their part in the administration of the various branches of public and economic life. In all these spheres my task is to promote science. But only in part of one of these spheres of activity—that of Government—have I the power to achieve this by the use of authority as distinct from encouragement, diplomacy, enthusiasm, example, precept or advice.

Secondly, after two years as Lord President of the Council I would say that, if only because of the very multiplicity of scientific disciplines, Government Science, and perhaps all British Science, is at the moment too parochially minded, too departmentalized and lacking in the broader vision. The Research Councils (D.S.I.R., M.R.C., A.R.C., O.R.C. and Nature Conservancy) and the Atomic Energy Authority are by their very terms of reference limited in their spheres.

However a Minister for Science is bound to look for a more generalized philosophy and approach if he is to succeed. In some ways the focus of scientific opinion in this country is the Royal Society. Long may it flourish. But for the purpose of advising the Government on scientific policy, the proper channel already exists in the form of the Advisory Council on Scientific Policy. I believe that this body provides one of the keys to the present situation, composed as it is of a unique connection of Government and non-Government scientists under an independent Chairman with a Vice-Chairman who happens also to be the Chairman of the Defence Research Policy Committee. I shall endeavour to rely more than ever upon the A.C.S.P. for generalized advice on questions of scientific policy.

My purpose is to make the voice of science coherent and articulate under Government encouragement, and in one real sense to make science self-governing under Government inspiration. For this purpose a greater use of A.C.S.P. is inevitable. I had already begun to move in this direction in the last Parliament. I hope to go further now, and I feel I am going to be helped by the more flexible and numerous office staff (which supplies the Secretariat of the A.C.S.P.) with which I shall be equipped as the result of the marriage between the Atomic Energy Office and the Lord President's Office. Thus assisted I shall try to tackle such questions as whether the general balance of scientific effort is right or could be better deployed, and other questions of a general nature as they emerge. Already in the last Parliament I had pressed forward an enquiry under the late Sir Claude Gibb (now chaired by Sir Solly Zuckerman) on techniques of management and control of Government financed research and development, and I look forward to a report from them, with positive suggestions, when they have completed their heavy task.

One of the matters I referred to the A.C.S.P. in the last Parliament was the question of space research, and it was as a result of their advice that the Steering Group under Sir Edward Bullard was set up and the group of scientists under Prof. Massey paid their recent and successful visit to America. I am not sure that either the philosophy or scope of our policy on space research is yet fully understood, and I would welcome the opportunity of expounding it more fully should questions be directed to me.

Lord Hailsham

I also have great hopes of the Overseas Research Council which I set up at the end of the last Parliament under the Chairmanship of Dr. Aitken. The object of this body is to act as a sort of clearing-house for our research effort overseas both separately and in co-operation with other countries.

I also hope to show a personal interest in the applied research which is very widely carried out by private industry and in industrial research associations under the general authority of the D.S.I.R. But execution of all this work will continue to rest with the bodies entrusted by Parliament with those functions.

In many ways the clue to the picture of science in this country lies with the Universities—especially with those which have great potentialities for growth and indeed an increase in numbers. To explore this in any detail would be outside my present purpose and indeed outside my function as the Minister for Science. I have no authority over the Universities nor over the University Grants Committee and I have no ambitions to obtain such authority. But I shall try to forge friendly links with both, both personally through individual contacts, and by discussions between officials. In particular, I have ideas for the forging of closer links between the Government Research Stations and Institutes, and the Universities, from which I believe both the Government Stations (and the scientists who work there) and the Universities would stand to gain in prestige and in effectiveness.

I also believe that the time has come for the purse strings of private munificence by industries and industrialists to be opened again for the benefit of universities and colleges and I will do all in my power to produce interest in this. My object here is not to limit the amount of Government help, but to widen the front of public interest, and increase academic independence and flexibility. It would be ungenerous and at

(*Concluded on page* 425)

A NEW APPROACH TO VAN SLYKE'S APPARATUS

by H. C. F. Usherwood

IT is a tribute to Dr. D. D. Van Slyke that the apparatus which he described in 1932[1], and the techniques which he evolved, are still in current use in clinical pathology laboratories all over the world.

The accuracy of the Van Slyke manometric apparatus is probably unsurpassed in the determination of gas contents and tensions in biological fluids, and because of this, the original glassware design is strictly adhered to by users.

The first major improvement in the Van Slyke manometric apparatus was recently made possible by the use of the new powerful sintered magnets[2]. Instead of agitation of the sample-plus-reagent mixture in the reaction pipette being effected by rapid reciprocation of the latter, the method of magnetic stirring was incorporated. Great care was necessary in the changeover to magnetic agitation since, as previously mentioned, users would not tolerate any change in the design of the glassware.

It is readily apparent that many advantages[3] are gained by the adoption of magnetic stirring, including silence, speed, and reduced breakage of glass parts. It is due, however, to the original thinking of J. H. High[4], Chief Chemist of the Hawker Siddeley Nuclear Power Company, that the most important aspect of the change may now be exploited.

Van Slyke[5] designed an attachment to the reaction pipette which was used for the determination of oxygen and hydrogen by a combustion method. This has been very little used, probably owing to the complications resulting from the need for a flexible coupling between the stationary attachment and the moving pipette.

Now that the pipette also is stationary, however, not only does the technique become simpler and more accurate, but a completely new order of determinations becomes possible. Mr. High's invention has been the incorporation of a subsidiary gas reservoir (SGR) to the reaction pipette, which immediately gives the whole apparatus immensely greater versatility and improved accuracy with reduced time spent on calculations. Indeed the inventor has himself already found a wide scope in industrial applications, and other workers are following suit. Fig. 1 shows a line drawing of the attachment; the filament assembly is replaced by a blank stopper for work not involving combustion. Fig. 2 is a photograph of the complete apparatus.

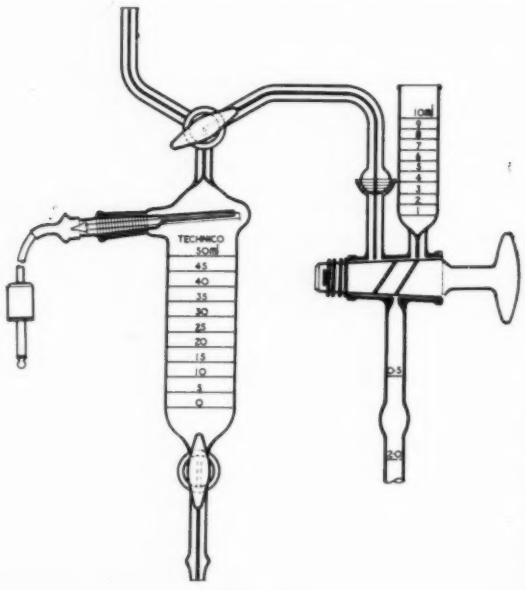

Fig. 1.

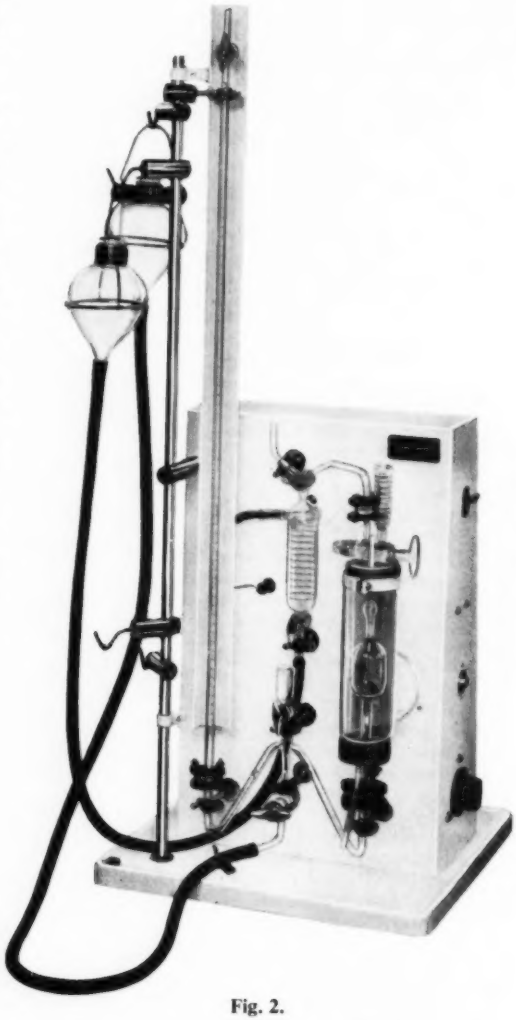

Fig. 2.

Case I. The successive determination of components in a mixture of gases.—A measured volume is drawn into the pipette and one component is absorbed. The remaining gases are transferred to the SGR and the reagent expelled from the pipette. The gases are then transferred back to the pipette and the pressure noted, so giving the percentage of that component. The procedure is repeated for the other components.

Case II. Avoidance of the calculations to correct for the volume of reagent used.—No matter whether the reagent is an absorbing or liberating liquid, the gas remaining after agitation is temporarily transferred to the SGR in order that the liquid may be expelled and the pipette rinsed (if necessary). After transferring back, the pressure may be read and no correction is then needed.

Case III. Qualitative determination of a gas identity.—In a mixture of, say, nitrogen, carbon dioxide and a low paraffin gas, the mixture is measured in the pipette. It is then transferred to the SGR and burnt with excess oxygen at reduced pressure. As in case I, the remaining oxygen may be absorbed and removed.

Suppose the paraffin to have been ethane:

$$2C_2H_5 + 13O_2 \longrightarrow 4CO_2 + 5H_2O$$

2 vols. 4 vols.

The water evolved is discounted because the space is saturated with water vapour both before and after the reaction. The identity of the gas is revealed since in every case the volume relationship is specific for each individual hydrocarbon number. Conversely, of course, in this example, if the identity of the gas be known prior to combustion, then its proportion may be calculated by observing the volume of the CO_2 produced.

Case IV. The accurate determination of trace dissolved gases.—Where the volume of gas liberated is too small to measure the pressure with real accuracy, it is transferred to the SGR and another liberation is made in the pipette. This too is transferred, and so on. In this way, the volume may be multiplied indefinitely.

Case V. Quantitative determination of trace absorbable gas in an inert atmosphere.—One successful example of this is the determination of trace CO_2 in argon. By absorption of CO_2 from successive samples, as outlined in case IV, and subsequent determination, it has been possible to analyse down to 1 p.p.m. accuracy.

Case VI. Quantitative determination of trace combustible gas in incombustible atmosphere.—To estimate hydrogen contamination in carbon dioxide, the CO_2 may be successively absorbed until a measurable volume of H_2 remains. It is possible to estimate as low as several microlitres per litre of carbon dioxide.

The above are but a selection of many new techniques which have become apparent. In all cases, the manipulation is simple, largely due to the separate mercury reservoir on the SGR which enables gases to be drawn in or expelled at will, regardless of the pressure obtaining in the reaction pipette. Bearing in mind that a 0·5 per cent component can be determined to 1 per cent accuracy in a large number of cases and that the effective range of the apparatus now extends from parts per million up to 100 per cent, the new versatility clearly indicates that it would be worth while considering this modified apparatus in many cases where other methods of gas analysis have hitherto been used.

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The modified Van Slyke-High apparatus described and illustrated is available only from A. Gallenkamp & Co. Ltd., Sun Street, London, E.C.2.

BOOK REVIEW

Ion Exchange—A Laboratory Manual, by J. E. Salmon, Ph.D., F.R.I.C., and D. K. Hale, M.A. London; Butterworths Scientific Publications, 1959. 25s. pp. 136 + vii.

This is an excellent introduction to ion exchange work. The growing use of ion exchange methods in many fields of technology makes it imperative that students should learn something about these materials during their practical chemistry courses.

The authors have struck a nice balance between the theoretical treatment necessary for an understanding of ion exchange processes and the detailed practical information required to make the subject interesting to practical chemists. They have placed a proper emphasis on the need for an experimental decision as to whether a given separation on an ion exchange column is possible, while at the same time they give a brief outline of the detailed theory of elution from an ion exchange column.

The first four chapters contain an outline of the general principles of ion exchange, of the preparation of ion exchange resins—with experimental details with which the student could make his own resins, of the properties of the resins and of ion exchange columns.

The remaining seven chapters give details of experiments for illustrating a variety of ion exchange techniques, together with many clear diagrams of apparatus and discussions of the most suitable type of equipment for a given process. The experiments given are comprehensive except perhaps that a place might have been found for the use of a mixed ion exchange resin column for the removal of salts from colloid sols. This technique is of such great importance in modern biochemistry eliminating as it does, days of dialysis of colloid preparations against running water, that there seems a good case for including it in an elementary textbook.

A list of references to the literature is given at the end of each chapter so that the more advanced student or research worker can find his way into the literature of ion exchange. Only one minor typographical error was noted. This book is strongly recommended as the basis for an introductory course in the theory and practice of ion exchange.—L. SAUNDERS.

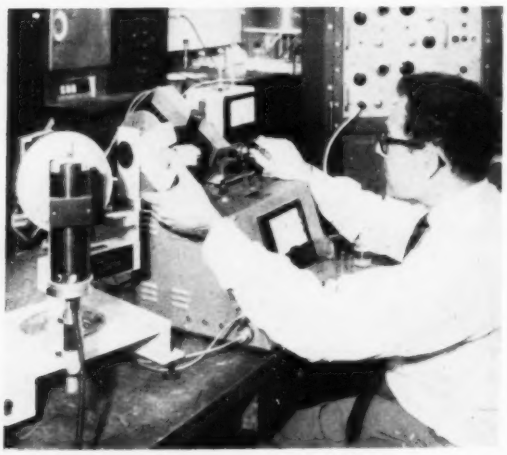
CORROSION RESEARCH

To provide science and industry with solutions to some of the practical engineering problems encountered today, the National Bureau of Standards is investigating the primary processes of corrosion. Large single metal crystals are employed in some of the research to correlate corrosion with the arrangement of atoms in the crystal lattice. The role played by electrical phenomena and cathodic protection comprise a phase of the programme. One study deals with the nature and mechanism of formation of oxide films on metal surfaces. The effect of illumination on the corrosion reaction has also been studied. By attacking the problem from different directions, the Bureau's corrosion research staff hopes to improve present methods for combating corrosion.

SINCE metals were first used for industrial purposes, man has waged constant warfare against the forces of corrosion. This complex process has been defined as the destruction of a metal by chemical or electrochemical reactions with its environment; and deterioration often proceeds in direct proportion to the aggressiveness of the environment. Essentially, corrosion is process metallurgy in reverse. Iron, for example, occurs in nature generally as oxides or hydroxide, and is refined to the steels of structural use. When exposed to a corrosive environment, the metal tends to revert to these original forms, which are than called 'rust'.

Corrosion is a serious and costly aspect of any nation's economy. The continuous depletion of ore reserves is only one factor to be considered. Wages, the 'down time' of equipment, and replacement costs must also be taken into account. It has been estimated that the annual cost of corrosion in the United States runs to billions of dollars. Of course, exact figures on the total cost are not available, but in the underground pipeline industry alone reliable estimates show the expense of replacement to be about 600 million dollars a year.

To aid in the solution of this problem, the National Bureau of Standards has for many years conducted a programme of research on the fundamental mechanisms of corrosion and the corrosion properties of materials. Now under the direction of G. A. Ellinger, this programme emphasizes basic processes and principles, seeking to discover why metals corrode and how corrosion can be prevented. Current studies deal with such topics as the corrosion reactions at the metal surface, electrochemical polarization and other electrical phenomena associated with corrosion, the effects of free radicals on metals at low temperatures, the nature of corrosion in large single crystals, and the mechanism of stress-corrosion cracking. By attacking the problem from these various directions, the Bureau hopes not only to improve methods of combating corrosion, but also to obtain basic data on the properties of matter that may be useful in other fields.



Corrosion reactions on the surface of metal single crystals are studied with this polarizing spectrometer. Here Jerome Kruger is making potential measurements while simultaneously measuring film thickness with the spectrometer. The specimen is held in the apparatus to the left.

One of the first corrosion studies at the Bureau was on the 'season cracking' of brass, a form of stress corrosion that affects the grain boundaries of brasses in a selective manner. Another early investigation, undertaken at the request of the Congress, explored the electrolytic corrosion of steel by stray electric currents. This work developed into an extensive soil corrosion programme which continued until 1952. More than 300 reports containing information gained during this effort have been summarized and published in NBS Circular C-579, *Underground Corrosion*[1].

One long-range investigation, on the corrosion of aircraft alloys, was started during World War I when metallic materials were first considered for aircraft and is still continuing under the sponsorship of the Bureau of Aeronautics, Department of the Navy.

Single Crystal Studies

As the corrosive process is influenced by many factors, a study of metals in their commercially usable state affords little information on the fundamental nature of the process. Such information can best be derived by studying the least complex form of the metal that has the basic characteristics of the whole, that is, metal in the form of single crystals. In this way, many of the corrosion-influencing factors of polycrystalline materials can be isolated, and reproducible results can be obtained.

Single crystals are being used in research initiated at the Bureau in 1955 under the sponsorship of the Corrosion Research Council. Chosen to investigate the adsorbed layers that form on metal surfaces was the metal-water-oxygen system. Copper was selected as the metal because it has a face-centred cubic structure, is readily available in high purity, and the corrosion products formed are few and simple.

Spherical specimens were initially employed in this work because they permit all of the crystallographic planes to be studied simultaneously. When carefully cleaned and polished specimens are exposed to water containing oxygen, different

oxide interference colours appear on the various planes. Each colour, readily identifiable from the patterns that are formed, indicates a different rate of growth of the corrosion products.

In one study, experiments were carried out both in open vessels exposed to the atmosphere, and in a closed all-glass apparatus in which the surrounding atmosphere and purity of the water were rigidly controlled.[2] The differences in the composition and nature of the films that formed on similar specimens were attributed to the presence of carbon dioxide in the laboratory atmosphere in the first experiment, and its absence under the controlled conditions of the second. During this study it was discovered that light has a marked inhibiting effect on the corrosion process.[3]

A related effort, undertaken as part of the Bureau's free radicals research programme[4], is concerned with the influence of atomic oxygen on metals at low temperatures. In this work oxygen is made to pass through a microwave discharge in order to dissociate some of the oxygen molecules. Initial experiments indicate that some reaction does occur between atomic oxygen and copper crystals cooled to 4·2° K. No reaction occurs, however, with oxygen which has not been passed through the microwave discharge. This area of investigation is expected to produce interesting and fruitful results.

In these single-crystal studies, a polarizing spectrometer is used to observe and measure the rate of film growth. This instrument has also been found useful in obtaining data from which the index of refraction of thin gas films can be calculated.

Other work with single crystals has been conducted to study the relationships between surface atomic arrangement and rates of corrosion in acids and alkalis.[5] When large single crystals of high-purity aluminium were exposed to an acid mixture, the configuration of the etch pits that formed on the surfaces differed according to the crystallographic orientation of the specimen. The rates of corrosion on these surfaces varied radically from the rates observed on atomically similar surfaces exposed to an alkali mixture.

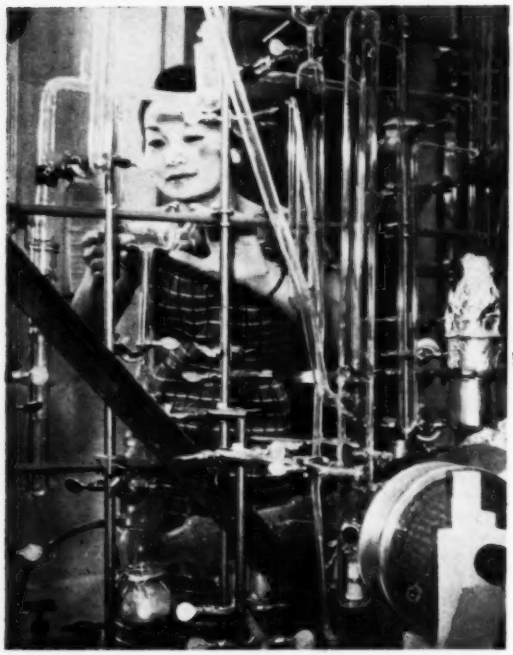
Part of the equipment used in single crystal research for the free radicals programme. W. J. Ambs is inserting a liquid helium cold finger into the apparatus to study the effect of atomic oxygen on metals at low temperatures.

The cylindrical specimen is an aluminium single crystal grown in a vertical furnace. Specimens in the form of discs, like the one held to the left, are cut from the crystal and subjected to corrosive media to determine the effect of crystallographic orientation on rates of corrosion. The different shapes into which the specimens corrode (foreground) depend on both the orientation of the specimen and the corrosive medium. Spherical specimen (above bar) corrodes in the shape shown to the right when exposed to an aqua regia-hydrofluoric acid mixture.

During an experiment with the corrosion of monocrystalline copper in an acid,[6] copper was electrodeposited on the specimen surfaces in an attempt to distinguish more readily the facets exposed as a result of attack by the acid. An analysis of Laue back-reflection diffraction patterns showed that the microstructure of the deposit either duplicates the orientation of the base crystal or has a continuing and twinned relationship with it. During the course of this research, equipment was developed for growing preferentially oriented metal monocrystals of practically any cross-sectional shape.[7] A pre-selected orientation was obtained with a technique known as 'seeding', and the desired cross-sectional shape was produced by growing the crystals in a vertical furnace.

Galvanic Corrosion

Even the purest metals have many foreign atoms within their lattices. Less pure metals contain non-metallic inclusions, metallic impurities, and other inhomogeneities. Exposure to a corrosive medium of dissimilar metals in contact with each other, or of a metal with surface inhomogeneities causes galvanic (electrochemical) corrosion. Such corrosion can also occur on metal surfaces exposed to non-uniform electrolytes with variations in electrical conductivity, etc. The electrical current associated with corrosive action causes the metallic area with the more anodic solution potential to dissolve, forming a pit in the metal surface. The depth of pitting depends on the amount of current that flows from anode to cathode, which in turn may depend on several factors such as anode-to-cathode area, environment, temperature, and



June Y. Chung evacuates the apparatus used for studying film growth on copper single crystals under controlled conditions.

pressure. When the mechanism that causes the first pit to form can be determined, a great advance will have been made in understanding the corrosion process.

Galvanic corrosion which occurs on a continuous metallic surface cannot be measured directly. However, the Bureau has developed a method for evaluating this corrosion indirectly, on ferrous surfaces at least.[8] In this method, the currents associated with the changes-in-slope in current-potential curves that occur during cathodic and anodic polarization are measured, and the values of applied polarizing current thus obtained are used to calculate the equivalent corrosion current. This indirect technique has been successfully applied in measuring the corrosion rates of steel in low-resistivity soils and in salt water. A variation of 10 per cent in corrosion rate can be detected in this way.

Now under investigation are the polarizing characteristics of iron specimens alloyed with chromium in various amounts up to 20 per cent, together with a similar series that contains, in addition, 3·5 per cent of silicon. Efforts will be made to use the indirect polarization technique to evaluate other factors affecting corrosion rates. Such factors include temperature, aeration and motion of the electrolyte, heat treatment, and alloying constituents of the basis metal.

One galvanic corrosion study deals with criteria for the cathodic protection of metals, principally ferrous metals. Although cathodic protection is based on well-founded scientific principles, its application has been the subject of considerable discussion. Insufficient negative potential gives inadequate protection, yet maintaining a greater potential than is required is unnecessarily costly. In investigating the problem, Bureau scientists have made a series of electrical measurements to evaluate the criteria of cathodic protection.[9]

In a part of this work it was found that steel exposed to soil environments varying in pH between 2·9 and 9·6 can be protected from corrosion by maintaining the steel at an electrical potential of —0·77 volt relative to a saturated calomel reference cell. Recent laboratory experiments showed that —0·77 volt is also the optimum potential for protecting steel in salt water.[10]

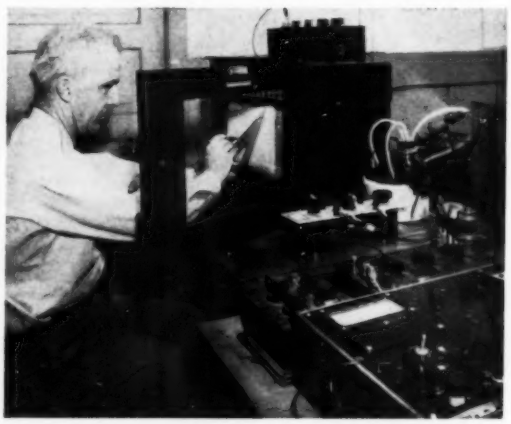
Stress Corrosion

The crystal structure of metals has a direct bearing on stress-corrosion cracking, a particularly damaging type of failure resulting, as its name suggests, from the combined effects of stress and corrosion. Cracking may be either intercrystalline, as in aluminium alloys and low-carbon steels, or transcrystalline, as in magnesium alloys and stainless steels. Of particular interest are the copper-zinc alloys, in which the attack is intercrystalline in the alpha phase and transcrystalline in the beta phase.

Residual or applied tensile stresses—frequently far below the yield strength of the material—may produce this type of failure even though the corrosive effect itself is very mild. Specific environments are often required, but in some cases a number of different media may cause cracking. Most investigators agree that practically all metals and alloys are subject to this failure when the necessary combination of stress and corrosion is present.

When most metals are exposed to ordinary atmospheres, a thin oxide covering quickly forms that tends to protect the metal from further corrosion. Stress-corrosion cracking apparently starts with a scratch or break in the protecting film. In investigating this type of cracking in several metals, the Bureau found that the process usually is continuous to complete failure.[11] However, if shifts in stress concentrations permit repair of the film from time to time, the process may be discontinuous.

For years stress-corrosion cracking has been a problem in the production of wrought-brass articles. During spinning and deep drawing, stresses are set up which remain in the metal unless removed by annealing. In studying this problem, the relationship between crystallographic orientation and cracking of both alpha and beta brasses was investigated.[12]



Polarization techniques are used to determine indirectly the rate of galvanic corrosion. Here the instantaneous rate of corrosion of an iron specimen immersed in salt water is obtained by W. J. Schwerdtfeger from the polarization curve obtained with a two-pen recorder.

Experimental results showed that the intercrystalline cracking in alpha brass apparently depends on the relative orientation of the crystals bordering the cracks, and hence on the crystal boundary energy. In beta brass, transcrystalline cracking occurs in crystals orientated most favourably for slip, and in planes that are approximately normal to the applied stress.

Experiments conducted for the Corrosion Research Council with a magnesium alloy indicated that the development of cracking is dependent upon strain rate.[13] However, these studies present very strong evidence that stress corrosion is partly an electrochemical phenomenon and not one of mechanical fracture only.

Recent work on austenitic stainless steels[14] for the Pressure Vessel Research Committee disclosed that sporadic but repeated creep in favourably oriented areas may rupture the protective film. This rupture provides a small film-free anodic area where stress corrosion can begin. By making the stressed steel become the anode in an external circuit, the corrosion can be accelerated. On the other hand, the corrosion can be prevented or stopped by application of a cathodic current.

Stress corrosion studies include exposure of specimens, principally aircraft alloys, to an urban atmosphere at Washington, D.C., and to a marine atmosphere on the Atlantic Ocean at Kure Beach, North Carolina. These studies are quite limited, however, in comparison to the main effort, directed toward developing fundamental data on the complex corrosive process.

Future Plans

In the near future, the Bureau expects to investigate corrosion inhibitors of the precipitate or barrier type. This work will explore the kinetics and energy associated with the formation of the precipitate, and the forces binding it to a metal surface. Additional corrodents will be studied in the work on aluminium single crystals, and single-crystal research will be extended to other high-purity metals.

A specimen in which most of the variables can be controlled has been devised for future stress corrosion studies. Investigations have been started on the influence of temperature and high pressures on the mechanism and kinetics of metal oxidation, as well as additional work on the reactions between atomic oxygen and metallic surfaces. The results of these and related studies are expected to provide science and industry with solutions to some of the practical corrosion problems that are causing concern today.

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The Minister of Science

(*Concluded from page* 419.)

this time insensitive not to point in this connection to the gifts rightly described as princely—including one particularly welcome fron the Transport and General Workers' Union, to Churchill College and to the project for St. Catherine's reconstitution at Oxford. But, greatly daring, may I say that I do not see why gifts from individuals and institutions should be concentrated on Oxford and Cambridge or even London? The greatest scope for enlargement and improvement surely lies elsewhere, as other generous and far-sighted benefactors have recognized.

The teaching of science and mathematics in the schools is again not a matter for me but for the teaching profession, and my contact with that profession must be through the Minister of Education, but I hope to keep a close liaison with the Minister in this and other matters, and I shall also try to seek guidance from the representatives of independent schools.

It is clear, I think, that in a single term of office only the foundation can be laid of a genuinely scientific approach to the problems of the present day. I hope that my ambitions in this direction will not be despised as inadequate because they are realistic and long-term. My hope will be to engender in all a genuine enthusiasm for science, and respect for scientific work and scientists not merely for their practical achievements, but also for the cultural values they represent. If I win their confidence, and also make clear to the public and to my colleagues the nature of their needs and their outlook, I will not have failed.

Royal Society Medals

The following awards of medals have been made by the President and the Council of the Royal Society:

The Copley Medal to Sir Macfarlane Burnet, O.M., F.R.S., director of the Walter and Eliza Hall Institute, Melbourne, Australia, for his distinguished contributions to knowledge of viruses and of immunology.

The Davy Medal to Prof. R. B. Woodward, For.Mem.R.S., of the department of chemistry, Harvard University, Cambridge, Massachusetts, U.S.A. for his distinguished researches in organic chemistry and particularly for his contributions to the structure and synthesis of natural products.

The Hughes Medal to Dr. A. B. Pippard, F.R.S., reader in physics in the University of Cambridge, for his distinguished contributions in the field of low temperature physics.

Laboratory Note-Book

A NEW oral penicillin, shown by clinical tests to produce greater antibiotic activity in the blood than has ever before been achieved with penicillins, has now become available in limited quantities.

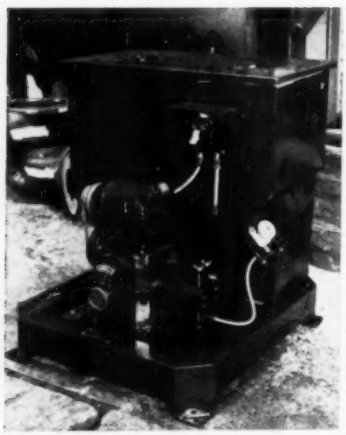
The new antibiotic, announced by Beecham Research Laboratories Ltd., is the first of the new penicillins built up from the basic penicillin molecule isolated last year by their scientists.

Its effectiveness is twice as great as that of penicillin V, the type now generally administered by mouth. After oral doses of the new penicillin, named Broxil (BRL.152), blood levels are superior to those following intramuscular injections of penicillin G, the type used in injections.

This new antibiotic is the first fruit of a joint research and development programme announced last spring between Beecham Research Laboratories in Great Britain and Bristol Laboratories Inc. in the United States. The news of its availability, just six months after the programme was set in hand, was announced simultaneously in London by Mr. H. G. Lazell, Chairman of Beecham Group Ltd. and Beecham Research Laboratories Ltd. and in Syracuse, U.S.A., by Dr. P. Bowman, President of Bristol Laboratories Inc.

Chemical Plant Hire Scheme

In recent years metering pumps have opened the way to new manufacturing methods and to the introduction of many new products where exactly controlled quantities of liquids must be introduced into manufacturing processes.



The plant available under the hire scheme is a packaged unit of an electrically operated variable stroke chemical injection pump together with solution tank and fittings.

Metering Pumps Ltd., of Ealing have now introduced a plant hire scheme to enable experimental chemists and industry in general to carry out experimental work in chemical dosing and to test the effectiveness of new processes in connection with their own specific needs. This plant hire service will save much initial expenditure on precision equipment before a process is fully tested. The plant available under this scheme consists of packaged units of an electrically operated variable stroke chemical injection pump, a 20 gallon capacity rubber lined mild steel solution tank, polythene delivery tubing and an injection fitting, all mounted on a mild steel frame. The heart of the plant is the pump and this is fitted with an ebonite pump head having a polished glass ram and synthetic rubber gland sealing rings. The pump can deliver from 0 to 3·75 gallons per hour against a pressure of up to 200 p.s.i. Any of six stroking speeds can be selected depending upon position of the two interchangeable triple groove pulleys and vee belt. These speeds are 22, 29, 38, 47, 60, and 76 s.p.m. In addition the length of stroke can be varied from zero to maximum either while the pump is in operation or at rest. The materials in contact with the liquid to be handled are ebonite, glass, synthetic rubber and polythene. All suitable for use in a wide range of applications. Hire charges are £4. 0s. 0d. per week plus transport to and from stores. During hire, service will be carried out at no additional cost and the Metering Pumps Ltd. technical advice service will be freely available.

Information Exchange

The United States Atomic Energy Commission and the United Kingdom Atomic Energy Authority have signed a five-year agreement to exchange technical information on advanced gas-cooled reactors.

The exchange, effective from November 16, 1959, will be carried out under the terms of the U.S.-U.K. agreement for co-operation in the civil uses of atomic energy, which has been in effect since 1955.

Data will be exchanged on development, design, construction and operation, as well as on related research and development, of the advanced gas-cooled reactors being built at Windscale, England, and on the U.S. experimental reactor project of this type at the Oak Ridge (Tennessee) national laboratory. Information exchanged under this agreement will be made available to British and American industry.

The agreement was completed during recent discussions in London and Washington by U.S. and U.K. representatives on matters of mutual interest in the civil uses of nuclear energy.

Centenary Exhibition

Norwood Technical College, Knight's Hill, S.E.27, is holding its Centenary Exhibition on December 16 and 17. The work of all the departments—literary, commercial, scientific and technical—will be on display and many well-known firms are contributing equipment. The exhibition will be open to the general public from 2.30-9 p.m. and will consist of films, models, displays, talks and many demonstrations.

Comprehensive Cover

A film embracing all stages of manufacture, from raw material to the moment the cartons are on high speed filling machines, has been made for Reed Cartons Ltd. The producer has avoided a traditional documentary approach to a manufacturing process by concentrating on quality control which ensures that the cartons come well within the extremely small tolerances permitted.

Keeping it Quiet!

One of the first tasks of the new £20,000 laboratory, opened at the Hemel Hempstead Development Corporation's industrial site, is to consider noise reduction in offices and ships.

Designed for investigation and research into all aspects of noise problems and built by the Acoustical Investigation and Research Organization Ltd., the laboratory will work in liaison with the National Physical Laboratory at Teddington and the Building Research Station at Watford. It comprises four experimental chambers and an underground test tunnel, and is claimed to be the only building in Britain where all the facilities for measuring noise were under one roof. The laboratory will offer a purely consultative service to industry and commerce.

A Scientific Prodigy

Instead of being promised a bicycle in return for good school reports, we read in the national press the other day of a 12-year-old American boy who is to have a scientific laboratory built in his home so that he can put the research he carries out during school hours into practice.

It seems that this boy (who is nameless at the special request of his father) has been solving Calculus problems since he was seven and is the despair of his school teacher who is reported as saying: 'He is too much for me. I cannot keep up with him, much less teach him.'

The laboratory is to be installed by his school and a firm producing parts for missiles. He is not to be left entirely to his own devices but will work under the supervision of the heads of three instructional sections of his school and the Dean of Students.

News from the British Association of Chemists

Proposed New Institute of Chemical Technology

A meeting of representatives of Technical Colleges training students for H.N.C. in Chemistry was held in the Crewe Arms Hotel, Crewe on Saturday, October 17, 1959 at 2 p.m.

The cost of the meeting was borne by individual members of the British Association of Chemists who had subscribed to a special fund opened for the purpose, and the chair was taken by the President of the B.A.C.

Earlier, a considered review of the position had been circulated by the Professional Status Committee of the Royal Institute of Chemistry. This review was critical of the proposed title and pointed out that many of the holders of National and Higher National Certificates in Chemistry entered one or other of the well-established professional bodies catering for specialized fields of technology so that it was extremely doubtful whether any substantial body of students remained uncatered for.

Nevertheless the Committee were of the opinion that the R.I.C. since it was unwilling to establish a permanent third grade membership, could not reasonably object to the formation of a separate association and should look with favour on its establishment. Moreover, if the writer may paraphrase the document, provided there was real evidence that the new institution would serve a useful purpose the R.I.C. would no doubt give advice and guidance on its development.

Partly as a result of this circular there was a remarkably good attendance at Crewe. Sixty colleges preparing students for H.N.C. in Chemistry sent representatives. Eight colleges sent their apologies, expressed interest and asked to be kept informed. Dr. Capper attended on behalf of the Ministry of Education, and Mr. Priestly of Leicester as observer on behalf of the Royal Institute of Chemistry. Some 20 members of the B.A.C. were present in an individual capacity.

A lively discussion took place.

There was general agreement that something should be done for students who had reached H.N.C. in Chemistry.

Following the lead of the Institute, there was general disagreement with the statement that 80 per cent of the students getting H.N.C. in Chemistry were left high and dry, since some students could not proceed further on personal grounds, others entered one or other of the various recognized Technological Institutes, such as the Textile Institute, The Institute of Fuel, The Institute of Petroleum, The Institute of the Rubber Industry, The Institute of Plastics, The Society of Dyers and Colourists, etc., etc., and no one knew just how many were left. It was suggested therefore that the R.I.C. and the B.A.C. should carry out a joint survey to ascertain the facts before proceeding further.

Advantages of Membership of the B.A.C.

Minimum Salary Scales.
Free Legal Advice on Professional Matters.
Appointments Service.
Unemployment Benefit.
Negotiations with Employers.
Group Scheme for Private Medical Treatment.
Certain advantages in connection with Insurance.
Trading Scheme.
Benevolent Fund.
Lectures, Discussions and Social Functions.

There was considerable criticism of the proposed title, since there was doubt as to its precise meaning, and since in any case the Technical Colleges lacked adequate technological equipment to cater for all the possible technologies. It was suggested therefore that a more appropriate title might be The Institute of Applied Chemistry.

Finally a vote was taken on the proposal of Mr. Andrews of Doncaster that this meeting is in favour of establishing a new Institute of Applied Chemistry.

This motion was carried by 24 votes to 23.

Mr. Bottomley of Widnes then proposed that the R.I.C. be asked to reconsider its decision not to open a permanent third grade of membership.

This was carried by 35 votes to eight.

The conclusion appears to be that while the meeting were agreed that something should be done, they would prefer to have it done by the R.I.C. Failing suitable action by the R.I.C. however, a considerable body of opinion were in favour of forming a new institute.

This institute would offer part-time students who had reached H.N.C. in Chemistry an alternative course to that offered by the R.I.C., a course broad rather than deep, leading ultimately to a qualification equivalent to the Dip. Tech. for day students.

All correspondence and enquiries concerning this Association should be addressed to G. R. Langdale, Esq., The British Association of Chemists, Nomination Dept., 14 Harley Street, London, W.1. Tel.: Museum 7021.

A Steering Committee was then formed consisting of 12 representatives of Technical Colleges and six representatives of industry. The R.I.C. will be asked to nominate a representative or representatives. Mr. John Wilson will act as Honorary Secretary for the time being. Dr. Robinson will act as Honorary Treasurer. This Committee will consider detailed proposals and make the necessary decisions.

The new body will be completely independent of the B.A.C.

It is hoped that it may be possible to give a précis of the actual discussions later.

42nd Annual General Meeting

The 42nd Annual General Meeting of the Association will be held at the Midland Hotel, Birmingham on December 12, 1959 at 2.30 p.m.

Annual Dinner

The annual Dinner of the Association will be held at the Midland Hotel, Birmingham on Friday, December 11, 1959 at 7.30 for 8.0 p.m.

Scientists Talk about Collective Bargaining

(*Condensed from Chemical & Engineering News*)

John W. Riegel, of the University of Michigan, has recently published a review entitled 'Collective Bargaining as Viewed by Unorganized Scientists and Engineers,' published by the Bureau of Industrial Relations, University of Michigan ($4). While about four out of five of the 264 personnel involved opposed collective bargaining for professional employees, over 20 per cent of those interviewed stated that they would be in favour of collective bargaining if conditions worsened. As collective bargaining in the U.S.A. is largely a feature of the last decade, Riegel points out that a depression might easily produce a majority in favour of collective bargaining. Several interviewees thought that professional societies should take an active part in salary matters.

Personalia

Life Member

The following has been elected a Life Member of the Association:

R. Wood. Aged 65. Elected Member 1919. (London Section).

Obituary

Blower, C. Aged 67. Elected Member 1919. (Manchester Section.)

Atherley, S. W. Aged 59. Elected Member 1927. (Notts. & Derby Section.)

Gould, C. E. Aged 64. Elected Member 1938. (Birmingham Section.)

LABORATORY EQUIPMENT & APPLIANCES

Philips Scintillation Detector

This instrument is designed for high energy, low intensity gamma spectrometry and measurement. It is intended for general use in the medical and biological fields, with special emphasis on localization measurement in the medical sphere.

It comprises the following elements: A large diameter, high resolution sodium iodide crystal (thallium activated) $1\frac{3}{4} \times 2$ in. high; an eleven-stage photo-multiplier; a built-in cathode follower; and a switch to disconnect the cathode follower. The latter is used with negative EHT to reduce thermal emission and a high impedance output is, therefore required.

(Sole distributors: Research and Control Instruments Ltd., Instrument House, 207 Kings Cross Road, W.C.1.)

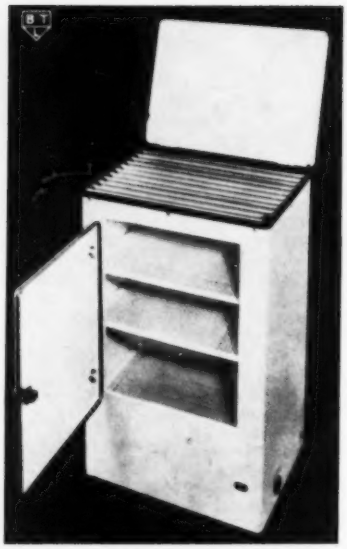
General Purpose Contamination Monitor

A new general purpose monitor, with a range of accessories permitting great versatility, has been developed. In addition to the monitoring of radioactive contamination, its applications include the assay of solids and measurement of activity in large or small samples of liquid. It is particularly suitable for such high sensitivity measurements as are needed for the assessment of radioactivity in evaporated water samples.

The monitor, Type PNI 1065, is fully transistorized. It is mains operated for normal factory, hospital or laboratory use, but there is alternative provision for running from a 12 volt battery. E.H.T. is adjustable over a range suitable for most Geiger Muller and scintillation counting applications; a scintillation counter preamplifier is included.

The count rate is indicated on a ratemeter with a range of from 0 to 1,000 counts per second; for low rates there is an electro-mechanical count register with a maximum operating speed of 25 impulses per second. The range of accessories being produced for use with the monitor includes lead castles, a liquid probe and a beta/gamma hand probe.

(Manufacturers: Plessey Nucleonics Ltd., Weedon Road, Northampton.)



Laboratory glassware drying cabinet.

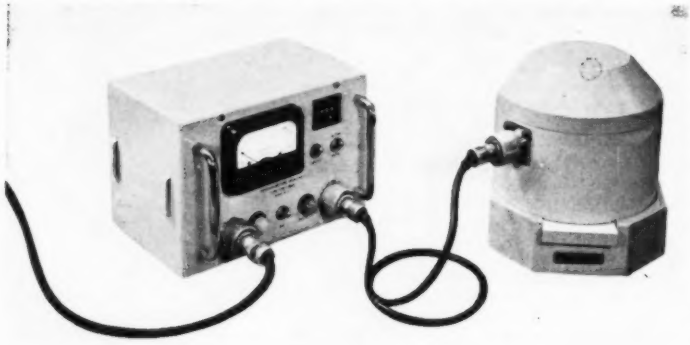
Drying Cabinet

A new drying cabinet for general laboratory purposes is now available. Designed for floor or bench use, the cabinet is supplied with three removable wire mesh shelves and the heavy gauge rust proofed case is fitted with a gasket sealed door with a conveniently operated spring-loaded catch. The shelves can be utilized for drying general laboratory glassware such as beakers, flasks and measuring cylinders. In addition, a hinged top is provided which gives access to seasoned beech rails located in grooves at the top of the cabinet, and these can be used, for example, for drying paper strips and cloths.

The cabinet relies on convection heating from heaters in the base of the equipment, and a three-heat switch and neon indicator allow temperatures of approximately 45°, 60° and 75° C. to be maintained. Special care has been taken to ensure adequate protection of the heaters against water spillage.

The exterior of the cabinet is finished in white enamel with blue trim, and is fitted with four floor castors for easy moving. It is supplied complete with nine feet of mains lead and a set of beech rails. The external dimensions of the cabinet are 35 in. x 20 in. x 15 in. approximately, and the interior working space is 25 in. x 20 in. x 15 in. approximately. The maximum consumption of the heaters is 1,250 watts.

(Manufacturers: Baird & Tatlock (London) Ltd., Chadwell Heath Essex.)



The Plessey G. P. monitor connected for use with a lead castle.

Philips Low-level Beta Counting Arrangement

This low-level beta counting arrangement is designed to measure low specific activities of radioactive materials, and has an extremely low background count of 1·5 per minute.

Special features include a new type of guard counter, a sample counter of extremely thin window (1·5 mg./cm.^{2}) motorized sample drive and low specific activity lead shielding.

It is suitable for many applications including C14 dating, tracer work, measurement of effluents, milk, foodstuffs, etc., and many other situations in the health physics and biological fields.

(Sole distributors: Research and Control Instruments Ltd., Instrument House, 207 King's Cross Road, W.C.1.)

Solid-free Water for Sterilizers

This unit is designed for the provision of solid-free water for sterilizers. Its purpose is to prevent deposits on syringes and surgical instruments during sterilization. Essentially this deionizer consists of a plastic base with tap water inlet and a mixed-bed exchange cartridge with top outlet for the purified effluent. Once connected to tap, the Top-It-Up provides solid-free (deionized) water instantly, at tap speed.

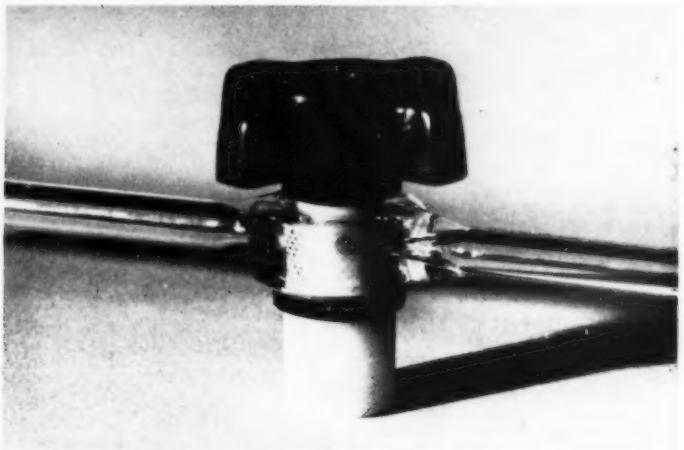
Effluent costs are negligible. Exhaustion point is shown by a colour indicator. The Elgalite cartridge service applies to this unit.

Cost of the Top-It-Up: £28.
(Manufacturers: Elga Products Ltd., Lane End, Bucks.)

Coiled Glass Capillary

Capillary columns for use in gas chromatography were first described by Golay in the autumn of 1957 (Golay, M. J. E. Gas Chromatography, p.1. (ed. V. J. Coates *et al.*). Academic Press, New York, 1958). The first practical chromatograms which he showed the following spring (Golay, M. J. E., Gas Chromatography, p. 36 (ed. D. H. Desty), Butterworths, London, 1958) aroused considerable interest and a period of intensive development has since taken place. In combination with the new ionization detectors, e.g. argon and hydrogen flame, they have revolutionized the analytical capabilities of gas chromatography and their potentialities in many industries are now being investigated (Desty, D. H., Goldup, A., and Whyman, B. H. F. To be published in J. Ind. Petroleum, preliminary announcement given in Nature, **184**, 327, 1959).

Although both metal and plastic tubes have successfully been employed for the columns, D. H. Desty and his co-workers at the BP Research Centre have developed a method of drawing long lengths of coiled glass capillary which looks very promising, particularly at high temperatures (Desty, D. H., Haresnap, J. N. and Whyman, B. H. F. To be published in Anal. Chem., preliminary announcement given in Nature, **184**, 327, 1959). By arrangement with BP Research Centre, these spirals are now being produced commercially and such tubing is available from stock having an internal diameter of 10 thou. and an external diameter of about 35 thou. in continuous lengths up to 500 ft. Other sizes are available to special order. At the moment, the glass spiral is only being supplied, but it is hoped that in the near future complete columns will be available mounted on a simple metal framework with rigid inlet and outlet ready for coating.
(Manufacturers: A. D. Wood (Scientific Glassware), 4-5 Skinner Street, London, E.C.1.)



The Watson-Marlow P.T.F.E./glass stopcock made by the Loughborough Glass Co., Ltd.

CATALOGUES, BROCHURES & LEAFLETS

Received from Manufacturers

Marconi Instrumentation.—The September 1959 issue of *Marconi Instrumentation* published by Marconi Instruments Ltd. of St. Albans, Herts., contains articles on atomic power instrumentation, the Marconi Ratemeter TF 1292, digital display of time or frequency and the Marconi TF 868B.

Oxoid New Products.—A number of new products have been added to the range of Oxoid products during the past 12 months and printed leaflets relating to these are available from Oxo Ltd., Oxoid Division, Thames House, Queen Street Place, London, E.C.4.

Laboratory News.—No. 3 (Third Series) of Towers Laboratory News has now been published by J. W. Towers & Co., Ltd., of Victoria House, Widnes, Lancs. Details are included concerning 'Labacta' blood agar base, stirrers, safety pipettes, Baker Sterimags, laboratory grain mills and contact thermometers and relays. The company have also issued a new catalogue dealing with their Streamline hydrometers.

Plastic Equipment.—A wide variety of plastic equipment for the laboratory, including such items as beakers, funnels, filtering flasks, pipettes, stirrers, stopcocks, test tube racks, trays and water carriers, is described in a catalogue issued by X-Lon Products Ltd., X-Lon House, 48 Gillingham Street, London, S.W.1.

'Scientific' News.—This publication is issued every other month by Scientific Supplies Co., Ltd., of Vine Hill, E.C.1, and spotlights recent additions and modifications which manufacturers of various ranges of laboratory apparatus have made. The November issue contains additions to Quickfit, E-Mil, Interkey and Whatman ranges; new items not shown in the general catalogue; and surplus stocks available at reduced prices.

NEWS

General

New Laboratory for C.W.S. Soaps

A new laboratory, housing a staff of 20 scientists and assistants has been built at the C.W.S. soap works at Irlam, near Manchester.

Well equipped and designed in a contemporary style, it replaces an old laboratory in which accomodation, both for staff and instrumentation, was inadequate for the ever-growing volume of testing and research work. Now the very latest equipment is set in a bright and spacious laboratory with modern labour-saving equipment and apparatus to enable the full staff to keep abreast of the increasingly complex trends in the field of industrial science.

Each class of soap or detergent in tablet, powder or liquid form, either for household or industrial use, is tested in this laboratory, before, during and after its production. Firstly, raw materials are checked for their quality standards on purchase, then for their correct mixtures in process during each stage of production and finally the finished products are examined for quality in all aspects.

A research section is set aside to cover research and development work on products and the plants producing them, to keep abreast of the changes and trends which are going on continuously in the industry. For operations in very specialized fields such as bacteriology, a close association is maintained with the C.W.S. Technical Research Department in Manchester.

Manufacturers' News

Mobile Demonstration Unit

Southern Instruments' new mobile demonstration unit equipped with a comprehensive range of recording instruments started its first journey on November 2. Mr. J. F. Orr and Mr. P. Linscott are in charge of this unit, and with the co-operation of the company's Scottish agents, Elesco Electronics Ltd., will be visiting various industrial and Government establishments in Scotland by request.

I.R.D. Amalgamate with Hilger & Watts

Hilger & Watts Ltd. have acquired the whole of the issued share capital of The Infra-Red Development Co. Ltd.

I.R.D. Ltd. was founded in 1946 and specializes in the analysis of gases by non-dispersive infra-red techniques, primarily for industrial purposes. From the start, the firm has been under the technical control and management of Mr. W. B. Bartley, who will remain managing director.

The pooling of knowledge and experience will be of great value to the two companies, and the technical, financial, and manufacturing resources of the Hilger & Watts organization will expedite further developments in gas analysis and their application in the expanding field of process control. In that field, dispersive infra-red techniques are also likely to become more important.

The Infra-Red Development Co. Ltd. will continue to operate at its works and offices in Welwyn Garden City and to develop and manufacture gas analysers.

Visit to Plessey Nucleonics

Plessey Nucleonics Ltd. was formed in 1956 to centralize and consolidate the nuclear projects of the Plessey Group of Companies.

During the first years of the company's existence its main programme was the development of a system for the detection of failures in the fuel element cans of nuclear power stations. To this range of burst slug detection equipment has been added flux scanning equipment, radiation detectors of many types, health instrumentation, process control instruments using nuclear techniques, and the provision of complete nuclear instrumentation for research and power reactors, examples of which were seen during a recent visit to the company's factory.

The company is backed by an extensive Research and Development Department. Altogether the laboratories employ about a third of the total number of personnel; an unusually large proportion of the staff have the high technical and scientific qualifications necessary for work in nucleonics. This research effort enables the company to exploit effectively the lead it has gained in its field, and by expanding to provide a very necessary service for the nuclear industry.

The self-contained factory is at Northampton, where it is central relative to both the atomic energy industry and the power stations themselves. The extension opened by Sir John Cockcroft in July 1959 has nearly doubled the area. In addition to the counters and radiation studies laboratories, there is a full range of machine and assembly shops, with a clean assembly area for work in dust-free conditions. The company is backed by the manufacturing facilities of the Plessey Group as a whole. The group chemical and metallurgical laboratories are conveniently near at Caswell, allowing close collaboration on joint ventures.

Assembly of an ionization chamber.

Personal Notes

Mr. Stanley H. Elliott

Mr. Stanley H. Elliott, Managing Director of H. J. Elliott Ltd., manufacturers of E-MIL laboratory glassware, has just spent three weeks in Canada to take part in a special display of their products organized by Canadian Laboratory Supplies Ltd., in Toronto and Montreal.

'Canlab' decided to take up the stocking and distribution of E-MIL products following Mr. Elliott's visit in October 1958.

Southern Instruments' new mobile demonstration unit.

Publications

Adhesives

Mrs. Joyce Hurd, B.Sc., formerly with the British Scientific Instrument Research Association, has produced a useful book containing a comprehensive list of adhesives commercially available in Great Britain, a guide to their properties and fields of application. Also included is an index of trade names.

The handbook is available post free from the publishers, British Scientific Instrument Research Association, South Hill, Chislehurst, Kent at 20s. (U.K.) and 22s. 6d. sterling (abroad).

Physics as a Career

A second and revised edition of 'Physics as a Career' has now been written by Mr. N. Clarke, B.Sc., F.Inst.P., Deputy Secretary of the Institute of Physics (Chapman & Hall Ltd., pp. 79, price 8s. 6d.).

In addition to the general revision which has been made where necessary, a new chapter has been added on atomic energy and the chapters on professional education and technical college posts have been modified to take account of the important changes that have now taken place in the status of some technical colleges and in the general facilities in most.

A short chapter has also been added dealing with salaries.

Plastics in the Tropics

No. 11 in the series of Reports on Plastics in the Tropics has now been published for the Ministry of Supply by H.M.S.O. (price 5s.) and deals with cast acrylic sheet.

Sheets of cast methyl methacrylate, both plasticized and unplasticized, were exposed at four sites in the tropics for more than two years. One of the sites was a permanent building representing a tropical base depot store and a further set of specimens was kept for most of the period in a room with a controlled atmosphere. Specimens exposed in the desert showed discoloration and loss in transparency, particularly in the case of unplasticized sheets. At the two jungle sites there was less colour change and less loss in transparency. At the end of the trial, specimens from all sites had retained satisfactory resistance to impact. Under all conditions of exposure the plasticized materials showed loss of plasticizer of the same order. Specimens stored under base depot conditions remained free from biological attack, but at the jungle sites fungal and algal growths developed. Crazing was noted on specimens exposed in the jungle undergrowth, but this was not apparent under other conditions.

MEETINGS OF THE MONTH

Mid-December to Mid-January

We give below a selection of meetings of interest to laboratory workers. Details are as full as possible at the time of going to press, but readers requiring further information or confirmation of arrangements should contact the organizers.

December 8

The Society of Instrument Technology (Manchester Section). In the 'Manchester Room,' Central Library, St. Peter's Square, Manchester, 1. 6.45 p.m. 'Instrumentation of the Dounreay Reactor', by K. R. Sandiford, B.Sc.

December 9

The Society of Instrument Technology (Bristol Section). At the University of Bristol, Department of Physics, The Royal Fort, Bristol. 7.30 p.m. 'New Instruments for Old Processes', by A. E. Hidden, B.Sc.(ENG.).

The Society of Analytical Chemistry (Midlands Section). At the Wolverhampton and Staffordshire College of Technology, Wolverhampton. 7 p.m. Discussion on 'The Determination of Trace Impurities in Metals', to be opened by B. Bagshawe, A.Met., and W. T. Elwell, F.R.I.C.

The Society of Analytical Chemistry (Biological Methods Group). In the Meeting Room of the Chemical Society, Burlington House, London, W.1. 7 p.m. Annual General Meeting followed by an Ordinary Meeting on 'Biological: Methods in Forensic Science'. Speakers, H. J. Walls, B.Sc., Ph.D., S. S. Kind B.Sc., and A. S. Curry, M.A., Ph.D., A.R.I.C.

December 10

The Society of Instrument Technology (Liverpool Section). At the M.A.N.W.E.B. Industrial Development Centre, Paradise Street, Liverpool. 7.15 p.m. 'New Simple Transistorized Industrial Instruments', by A. Green.

The Society of Instrument Technology (Tees-side Section). At the Cleveland Scientific & Technical Institute, Corporation Road, Middlesbrough. 7.30 p.m. 'Practical Applications of Strain Gauge Weighing', by E. I. Lowe, B.Sc.(ENG.).

December 11

The Society of Instrument Technology (Midland Section). In the Lecture Theatre of the Byng Kendrick Suite, Gosta Green College of Technology, Aston Street, Birmingham. 7 p.m. 'Radioactive Isotopes in Industry', by W. G. Busbridge.

The Society of Analytical Chemistry (Western Section). At Cardiff. Joint Meeting with the Cardiff and District Section of the R.I.C. and the South Wales Section of the S.C.I. on 'The Work of the Railway Chemists' Department'.

The Royal Institution of Great Britain. At 21 Albemarle Street, London, W.1. 9 p.m. 'The Menace of Vibration in Engineering', by R. E. D. Bishop, M.A., M.S., Ph.D., D.Sc.(ENG.).

December 16

The Society of Instrument Technology (Newcastle Section). In the Conference Room, Roadway House, Oxford Street, Newcastle-upon-Tyne. 7 p.m. 'Discussion Night'.

The Society of Instrument Technology (London Section). At Manson House, 26 Portland Place, London, W.1. 6.30 p.m. 'Random Inputs and Load Variations', by J. F. Coales, O.B.E., M.A., M.I.E.E. F.Inst.P.

The Society for Analytical Chemistry (Microchemistry Group). At 'The Feathers', Tudor Street, London, E.C.4. 6.30 p.m. 'London Discussion Meeting'.

December 17

The Society of Instrument Technology (Chester Section). At the Grosvenor Museum, Chester. 7 p.m. 'Cost Control in Instrument Engineering', by S. Sheridan and J. Reed.

The Society for Analytical Chemistry (Midlands Section). At the Technical College, Nottingham. 7 p.m. Discussion on 'Kjeldahl Nitrogen Determinations', to be opened by R. A. Savidge, A.R.I.C., and H. C. Wilkinson, M.Sc., F.R.I.C.

December 19

The Society of Instrument Technology (East Midland Section). Visit to the Production Engineering Research Association, Melton Mowbray, 10 p.m.

January 4

The Society of Instrument Technology (Cheltenham Section). At the Belle Vue Hotel, Cheltenham. 7.30 p.m. 'Instrument Engineering at the National Institute for Medical Research', by W. C. Lister.

January 7

The Society of Instrument Technology (London Section). At Manson House, 26 Portland Place, London, W.1. 6.30 p.m. 'The Production and Assimilation of Meteorological Observations', by E. J. Sumner, B.A.

LABORATORY PRACTICE

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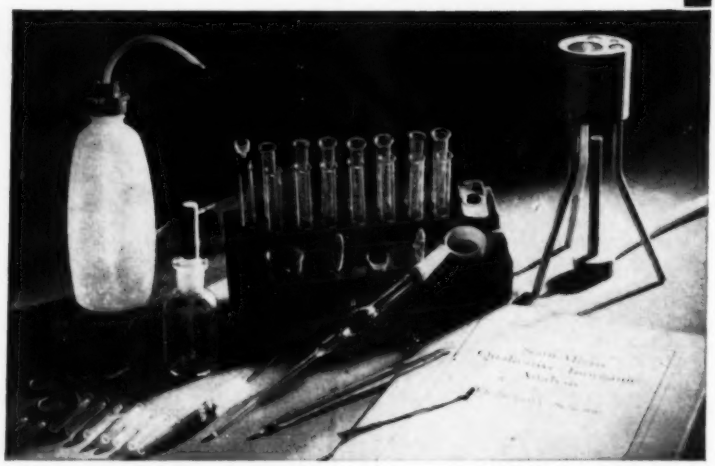

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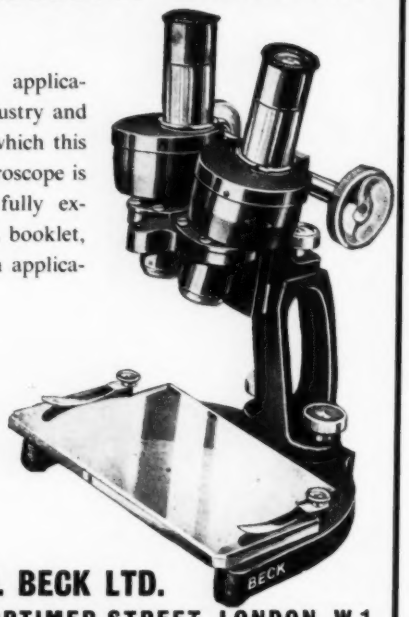

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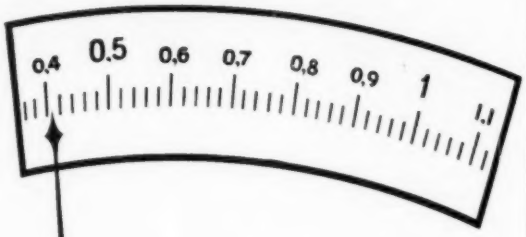

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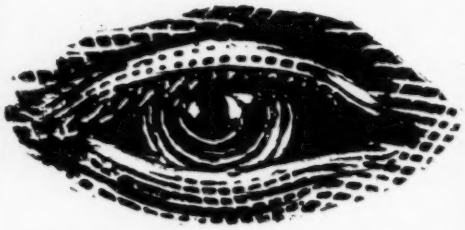

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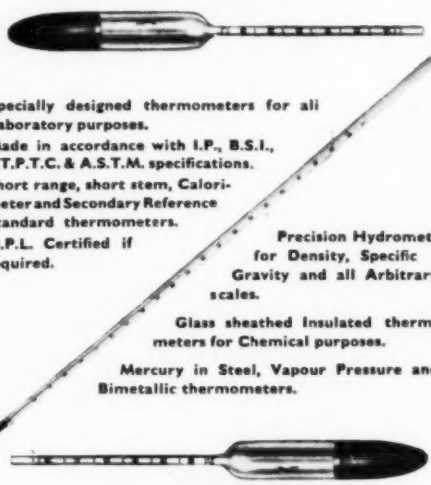

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